RADIUM THERAPY IN CANCER

AT THE MEMORIAL HOSPITAL

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AT THE MEMORIAL HOSPITAL

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RADIUM THERAPY IN CANCER

AT THE MEMORIAL HOSPITAL NEW YORK

(FIRST REPORT: 1915 - 1916)

BY

HENRY H. JANEWAY, M.D.

WITH THE DISCUSSION OF TREATMENT OF CANCER OF THE BLADDER AND PROSTATE

By BENJAMIN S. BARRINGER, M.D.

AND AN INTRODUCTION UPON THE PHYSICS OF RADIUM

By GIOACCHINO FAILLA, E.E., A.M.

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PREFACE

The somewhat detailed character of the present report has been determined by the urgent need of more accurate descriptions of the methods of applying radium to malignant tumors in different situations. The great majority of available reports indicate the total amount of radium employed, but details regarding concentration of radium to the unit of surface, the exact nature of filtration, the exact periods of repeated applications, and the successive steps of the therapeutic result, are incompletely presented or entirely omitted. Consequently it has been impossible for the reader to duplicate the method or to obtain the necessary information to guide him in his own work. Unfavorable results are experienced in all large radium clinics, but under exactly what circumstances such results may be expected, or how they may be avoided, has seldom been stated. Such information, it is believed, may be obtained from many of the case records of the present report.

It has become more and more apparent that the successful use of radium in cancer, requires careful consideration of each particular type of the disease in each organ as separate problems, in which different methods must be devised and different results expected. Hence the various forms of cancer are separately considered, and the indications, methods, complications, and results are given briefly for each.

In our experience the use of radium emanation has greatly increased the efficiency of radium therapy as compared to the use of the metal itself.

For a satisfactory understanding of these advantages as well as the principles of application and filtration an acquaintance with the physics of radium is indispensable. It has therefore been deemed advisable to include in this report an introduction explaining in detail the physical considerations relative to the therapeutic application of radium.

The author desires to express his indebtedness to Dr. Samuel Brown, to whose efficient services in making and changing the applicators and in following the patients much of the success of this work is due.

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RADIUM THERAPY IN CANCER AT THE MEMORIAL HOSPITAL

I

PHYSICAL CONSIDERATIONS RELATIVE TO THE APPLICATION OF RADIUM

GIOACCHINO FAILLA, E.E., A.M.

INTRODUCTORY

Considering the highly specialized character of the present report, it seems desirable to give a brief account of the principal phenomena of radio-activity, in order that the uninitiated may better appreciate their bearing on the treatment of cancer by means of the very penetrating rays of radium. As *x*-rays are very closely related to these radiations and at the same time their most important properties are well known by the medical profession, it is preferable, perhaps, to begin with a brief discussion of *x*-rays.

In the following pages it will be assumed that the reader is more or less familiar with *x*-rays and the terminology ordinarily employed in dealing with their properties. Nevertheless, some technical terms are defined and many others are introduced in such a way as to make their meaning plain from the context.

ROENTGEN RAYS

The study of *x*-rays and radio-activity has thrown much light on the baffling problem of the ultimate nature of matter. It is universally accepted now that the atom is a very complicated structure in which reside equal amounts of positive

and negative electricity. The negative electricity is divided equally among a number of identical corpuscles or electrons. These exceedingly minute corpuscles have been isolated and their properties studied. We now know that they are not material particles but that they consist of electricity in its ultimate form. The charge carried by all electrons is the same and is the smallest quantity of electricity so far known to exist. They have a definite mass which is wholly electromagnetic in nature and increases as the speed at which they are traveling increases. The mass of an electron at slow speeds is about 1/1800 that of the hydrogen atom, which is the lightest atom known. An idea of the relative size of the electron and the atom may be formed by comparing them to a fly and a cathedral respectively.

Ordinarily the electrons are attached to the atoms, but, under suitable conditions, it is possible to liberate at least some of them. Thus in an *x*-ray bulb, under the influence of a strong electric force, the positive ions bombard the cathode and the latter ejects a stream of electrons. These constitute the so-called cathode rays. The velocity of these electrons depends on the difference of potential applied to the *x*-ray bulb. It is enormous, reaching up to about $\frac{1}{3}$ the velocity of light, or about 62,000 miles per second.

Owing to the high speed at which these electrons travel, they possess a large amount of kinetic energy. If one of them is stopped by impinging on an obstacle in its path, it loses the energy which it possessed by virtue of its motion. But, since energy cannot be destroyed, an equal amount must reappear under a different form. We know from electrodynamics that whenever an electric charge is retarded or accelerated in certain ways radiation of electromagnetic energy occurs. When a swiftly moving electron is suddenly stopped, therefore, we should expect an electromagnetic disturbance of some sort to originate from the point of collision. This actually takes place, and the result is the generation of *x*-rays. But not all the energy of the cathode stream is transformed into electromagnetic energy of the *x*-ray type. As a matter of fact only a small fraction of the total goes into the *x*-rays generated. Some electrons are scattered back after hitting the target; some lose their energy gradually in breaking up (ionizing) atoms in the material; some spend their energy in agitating the atoms thus

producing heat. Probably it is only when an electron hits an atom squarely and is suddenly stopped that x-radiation is generated.

There are many experimental facts tending to show a close similarity between x-rays and ordinary light. In fact it may safely be said that there is no essential difference in the nature of the two and that both belong to a very large class of electromagnetic waves extending from the Hertzian waves employed in wireless telegraphy, which are several miles long, to the x-rays from radium, having wave-lengths of the order of 10^{-9} centimeter.* . Ordinary light has wave-lengths included between the limits 7.7×10^{-5} cm. and 3.6×10^{-5} cm., while the wave-length of x-rays is about 10^{-8} cm. Accordingly, then, the wave-lengths of x-rays are about 10,000 times shorter than the wave-lengths of ordinary light and are comparable to the diameter of the atom.

The experimental fact, which more than any other contributed to the universal belief in the electromagnetic nature of x-rays and their close similarity to light, is that of the diffraction of x-rays by means of a crystal, resulting in the production of an x-ray spectrum. It has been known for a long time that a beam of white light, passing through a diffraction grating in certain directions, gives a color spectrum ranging from red to violet. A diffraction grating of this sort consists of a plate of glass on one side of which a great many equally-spaced, parallel lines have been ruled by means of a diamond point. The number of lines is of the order of 10,000 per inch for ordinary work, the essential point being that the spacing between the lines must be comparable with the wave-lengths of the light to be analyzed. By this means it is possible to measure the wave-lengths of the different beams resulting from the original one. Naturally it was thought that if x-rays were electromagnetic waves like ordinary light, we should be able to analyze them by means of a

* 10^{-9} cm. $= 1 \times 10^{-9}$ cm. $= \frac{1}{1{,}000{,}000{,}000}$ cm. $= 0.000000001$ cm.

This concise way of expressing very small or very large numbers consists in indicating the number of places that the decimal point in the given figure is to be moved to the right or to the left by a positive or negative exponent respectively. Thus:

$$3.15 \times 10^{+5} = \underbrace{315000}_{+5 \text{ places}}; \quad 3.15 \times 10^{-5} = \underbrace{0.0000315}_{-5 \text{ places}}$$

grating. However, it was known from Planck's theory of radiation that, if *x*-rays were electromagnetic waves at all, their wave-length would have to be of the order of 10^{-8} cm. Clearly then it would not do to use the ordinary diffraction grating. Bearing this in mind, M. Laue of Munich conceived the idea of using a crystal with its regular arrangement of atoms for a grating to diffract *x*-rays. His predictions were brilliantly verified first by the experiments of Friedrich and Knipping. Since then a great deal of work has been done on this subject. It is possible now to measure the wave-length of *x*-rays with considerable accuracy. This is of great importance in determining the quality of *x*-rays because the penetrating power of the rays depends solely on their wave-length. The shorter the wave-length the harder or more penetrating are the rays.

The similarity between light and *x*-rays has received experimental confirmation of an entirely different nature. It is found that a beam of ultra-violet light falling on a metal causes the ejection of negative electrons from its surface. The same is true of a beam of *x*-rays but to a much greater extent. In both cases the initial speed with which the negative corpuscles are shot out depends only on the wave-length of the incident radiation. It is the same for all metals whether they are near the source of radiation or very far. But the number of ejected electrons depends on the substance and the intensity of the radiation.

In the case of *x*-rays the speed of these electrons is approximately the same as the speed of the electrons in the cathode stream which produced the *x*-rays. This is a very remarkable fact which deserves careful consideration. Electrons moving with a certain speed impinge on a metal plate and produce electromagnetic disturbances of a certain definite wave-length which are known as *x*-rays. These radiations travel through space with the velocity of light. If they encounter an obstacle—a metal plate, say—some electrons will be knocked out of the plate which have the same speed as the parent electrons. Since all electrons are alike, this means that the energy of one of these electrons at the time of its liberation is the same as the energy of one primary electron at the time of impact, no matter how far apart the two phenomena may take place.

Besides the corpuscular secondary radiation, other classes of

radiation are produced by a beam of *x*-rays striking a substance. These are of the same nature as the primary *x*-rays themselves. Really one class cannot be called a true secondary radiation because it is nothing more than a part of the primary beam scattered by the substance. The scattered rays are distributed in all directions, but the intensity in the forward direction is greatest, and sideways it is least. The scattering of *x*-rays is analogous to the scattering of light by a cloud.

The second class consists of *x*-rays which are characteristic of the substance upon which the primary beam falls. In general the characteristic rays, if excited, have not the same wave-length as the primary rays because the quality of the characteristic radiation depends solely on the material of the radiator. In order that the characteristic radiation shall be excited, it is necessary that the primary radiation be more penetrating than the characteristic radiation. For different metals the quality of the characteristic radiation is different; the higher the atomic weight the harder the characteristic rays. In general the characteristic radiation is made up of approximately monochromatic sets of rays (rays having the same wave-length). A good many metals give out two monochromatic radiations which are known as the K and L series of radiations because there is a correspondence between the K and L radiations of one element and those of another. For instance, the hardness of both the K and L radiations increases with the atomic weight of the radiator. The generation of characteristic secondary radiations by *x*-rays is analogous to the phenomenon of fluorescence in light. According to Stokes's law, the fluorescent light is always of longer wave-lengths than the light which excites it. There are a few exceptions to this law, but as far as we know there are none in the case of *x*-rays.

It has also been found that the characteristic radiation is excited directly by the cathode rays themselves. In general when a metal is struck by a stream of electrons moving with high enough velocity to excite the characteristic radiations, a general radiation is produced the quality of which depends on the speed of the electrons and the intensity of which is greatest in certain directions. At the same time characteristic rays are produced, some directly by the electrons striking the radiator, some indirectly by sufficiently hard rays of the general radia-

tion which have been generated in the deeper layers of atoms and which strike other atoms in coming out of the material. However, only a small part of the characteristic radiation is produced by this indirect action.

Still another point of resemblance between light and *x*-rays may be mentioned here: the ionization of gases. The atoms of a gas are ordinarily electrically neutral, that is, they contain as much positive as negative electricity. But under certain conditions some of the negative electricity can be separated from the positive in some atoms and then the gas assumes entirely new properties. An atom which has lost a negative electron becomes a positive ion. The electron through its motion through the gas gathers a cluster of atoms around it and becomes a negative ion. A positive ion may consist also of a group of atoms. The most important change brought about by the presence of these ions in the gas is with respect to its electrical conductivity. A gas whose atoms are all neutral is a non-conductor, but as soon as it is "ionized" it becomes a "conductor." The flow of electricity through the gas is due to the migration of the positive ions towards the negative electrode and the negative ions towards the positive electrode. Both ultra-violet light (of sufficiently short wave-length) and *x*-rays are capable of ionizing a gas through which they pass. The ionization produced by the latter, however, is much more intense. But it should be remembered that in any case the number of ions produced is only a very small fraction of the total number of atoms present—at the most only one atom in a billion is ionized.

The ionization of a gas by *x*-rays is due almost entirely to the action of the secondary electrons produced in the gas by the *x*-rays. We have already seen that *x*-rays are capable of liberating electrons from the atoms of a substance which they strike. The same thing happens in the case of a gas, and electrons are shot out in all directions with initial velocities depending on the quality of the parent *x*-rays. These electrons follow tortuous paths through the gas, owing to the collisions they make with many atoms. In the process, atoms are broken up into ions and the electrons are gradually slowed down. Finally, when they have lost so much of their energy in ionizing the gas that their speed has become too low to cause further ionization by impact, they attach themselves to atoms and become ions.

It is pretty well established now that the *x*-rays themselves do not produce ions directly and that the mechanism of ionization is the indirect one just described.*

Before leaving the subject of ionization it should be mentioned that ionization by *x*-rays, cathode rays and the rays of radio-active substances (as we shall see later), is not limited to matter in the gaseous state. Ions are also produced in solids and liquids through which these rays pass.

From what has already been said it is evident that the passage of *x*-rays (as well as cathode rays) through matter is accompanied by an absorption of energy by the matter and by a transference of energy to the secondary radiations which are excited. Energy is used up in making ions, agitating the atoms of the substance (*i.e.*, generating heat), and in producing secondary rays. Besides, a part of the incident radiation is scattered by reflection. It follows then that the intensity of the transmitted radiation must be smaller than the intensity of the incident radiation. The extent of the absorption of energy by the material varies with the substance, the thickness traversed and the quality of the rays.

For a beam of *x*-rays which is homogeneous before and after transmission, the absorption follows an exponential law. That is, successive layers of equal thickness of the material, absorb the same percentage of the radiation they receive. If the beam of *x*-rays is heterogeneous, that is, is made up of rays having different wave-lengths, the absorption is not exponential. But, as a first approximation the absorption of x-rays from an ordinary bulb may be considered to be exponential. The fraction of the incident radiation absorbed by equal thicknesses of different substances increases with the atomic weight of the absorber but is not directly proportional to its mass. Dense substances absorb more, mass for mass, than light ones. The increase is more marked with hard than with soft rays. Thus if we take a lead screen and an aluminium screen having the same area and the same weight, the absorption of hard *x*-rays by the former will be about 25 times greater than by the latter. (Note that if the absorption were directly proportional to the

* If we define the ion so as to include the secondary electrons produced by x-rays, we may say that x-rays produce swiftly moving ions directly and these produce more ions by colliding with the atoms in their paths.

density it should be the same in both cases.) The difference is less marked with substances of low atomic weight.

Besides this normal absorption there is a selective effect which has to be considered when the incident radiation contains rays having the same wave-length as one of the characteristic radiations of the absorbing substance. In this case the absorption is much less because there is a selective transmission by the substance of the radiation which it is capable of emitting when properly excited. On the other hand, the absorption is abnormally high for rays which are a little harder than the characteristic rays, but it is normal again for still harder rays. For softer rays the absorption increases with the wave-length and soon becomes normal.

It is instructive to consider for a moment the efficiency of the present methods of generating *x*-rays. It has been found that ordinarily only about 1/1000 of the energy of the cathode rays is transformed into radiant energy of the *x*-ray type. Most of the energy is dissipated into heat which is not only useless but very objectionable. The efficiency increases with the hardness of the *x*-rays and the atomic weight of the anti-cathode but it is independent of the current. Probably the efficiency of an ordinary *x*-ray bulb, as measured by the ratio of the energy of the *x*-rays produced to the electrical energy supplied to the bulb, is about 1/20,000.

RADIO-ACTIVITY

According to Rutherford and Bohr, an atom consists of an extremely minute nucleus or central structure of positive and negative electrons and of an outer system of negative electrons rotating around the nucleus in closed orbits (like the planets of the solar system). The number of the negative electrons in the outer system is such as to balance the excess positive electricity of the nucleus and is believed to be the same as the atomic number * of the substance. The number and disposition of these electrons determine the chemical and physical properties of the atom. The forces tending to keep them in

* It suffices to say here that the atomic number of an element represents the place which it occupies in the periodic table. It is about one-half the atomic weight of the element.

place are relatively weak so that, under suitable conditions, it is possible to alter their number or their arrangement. But the electrons in the nucleus are held together by very strong forces and cannot be affected by any means at our disposal. However, there are substances in nature whose atoms are in a transitory state, so to speak, and are continually "exploding." These atomic explosions are very violent and result in a complete rearrangement of the inner and outer systems of electrons in the atom usually accompanied by the expulsion of charged particles traveling at very high speeds and sometimes by radiations of the *x*-ray type also. These substances are said to be "radio-active." They are changing continually into physically and chemically different substances; now this atom breaking up, now that one, in a random way; but the number of atoms which disintegrate during sufficiently large equal intervals of time is always the same fraction of the total number present. Some substances disintegrate more slowly than others but each one disintegrates at a constant rate, whether it is very hot or very cold, whether it is free or in chemical combination with other substances. The products of this radio-active disintegration may themselves change into other substances, these into others and so on until stable substances are reached. They thus form "radio-active series." So far three such series are known: The Uranium Series, the Actinium Series and the Thorium Series. Of these only the first one is of interest to us.

For convenience the elements of this series may be arranged as shown in Table I,* page 20. This table is to be interpreted as follows: Given a certain quantity of Uranium 1, after 5.5×10^9 years half the original number of atoms have "exploded." Each atom in exploding gives off an alpha (α) particle and is transformed into an atom of uranium X_1. Each atom of uranium X_1 in turn breaks up, gives off a beta (β) particle and gamma (γ) radiation and changes into uranium X_2. Similarly for all the other members of the series. The half-value period is the time necessary for half the initial amount of each element to disintegrate provided it is isolated from the parent substance. Note that the ejection of an α particle re-

* This table is not complete because the branch products, which have little practical importance, have been omitted for the sake of simplicity. For a detailed discussion of the whole series the reader is referred to F. Soddy's "The Chemistry of the Radio-Elements."

TABLE I

Element	Radiation	Half Value	Period	Atomic Weight	Valency
Uranium 1	α	5.5×10^9	years	238	VI
Uranium X_1	$\beta + \gamma$	24.6	days	234	IV
Uranium X_2	β	1.15	mins.	234	V
Uranium 2	α	2.1×10^6	years	234	VI
Ionium	α	1.4×10^5	years	230	IV
Radium	α	1730	years	226	II
Radium Emanation	α	3.85	days	222	0
Radium A	α	3	mins.	218	VI
Radium B	$\beta + \gamma$	26.7	mins.	214	IV
Radium C	$\beta + \gamma$	19.5	mins.	214	V
Radium C^1	α	10^{-6}	sec.	214	VI
Radium D (Radio-Lead)	Slow β	15.83	years	210	IV
Radium E	$\beta + \gamma$	48.5	days	210	V
Radium F (Polonium)	α	136	days	210	VI
End	....	.....	.....	206	IV

sults in the reduction of the atomic weight by 4 and the valency by II. The ejection of a β particle does not affect the atomic weight but increases the valency by I.

An alpha (α) particle is nothing but a helium * atom carrying two unit positive charges of electricity. It is capable, therefore, of neutralizing two negative electrons. When it leaves the substance from which it originates it usually has a very high velocity. For instance, the velocity of the particles given off by Radium C is about 2×10^9 cm. per second, or about 12,400 miles per second. The beta (β) particles are negatively charged electrons which are shot out through space with enormous velocities. Those from Radium C have velocities up to 2.99×10^{10} cm. per second, which is nearly the velocity of light (3×10^{10} cm. per second = 186,000 miles per second). The gamma (γ) rays are of the same nature as x-rays but much more penetrating.

Note in the above table that every substance which emits γ radiation also gives off β particles, but that the converse is not always true. This seems to indicate that the generation of γ-rays is a secondary effect which may or may not accompany the expulsion of β particles from the substance.

In the uranium series the element of greatest practical impor-

* Helium is a very light inert gas found in small amount in the atmosphere and also in radio-active minerals.

tance is radium. This is a metal chemically very closely related to barium, but differing tremendously from the latter in that it is radio-active while barium is not. Its half-value period is about 1,700 years, which means that if we have one gram of radium to-day we shall have half a gram about 1,700 years from now. It follows then that radium itself is very weakly radio-active. As the atoms of radium disintegrate α particles are given off. The new substance which is formed in the process is a gas called radium emanation (or niton). The atomic weight of radium being 226 and that of helium 4, it follows that the atomic weight of the emanation must be 222. This value has been checked experimentally. The half-value period of the emanation is 3.85 days so that it is much more radio-active than radium. The emanation gives off α particles and radium A is produced. This is turn gives rise to radium B which gives off β particles and γ rays and changes into radium C. The transformation of radium C is rather complicated because a branch product is formed. About 99.97 per cent. of the Ra C changes to Ra C^1 and only 0.03 per cent. to Ra C_2 which is the branch product. For all practical purposes we may say that Ra B changes into Ra C, which has a half-value period of 19.5 minutes, gives off α, β and γ rays and turns into Ra D. The end product of the series is a substance indistinguishable from ordinary lead in its chemical behavior but having a slightly lower atomic weight (206 instead of 207.1).

Let us consider for a moment what happens when a certain quantity of radium, free of its subsequent products, is sealed in a glass tube. Since the radium is disintegrating all the time, as soon as the tube is sealed, the emanation which is formed cannot escape. For all practical purposes we may say that it is being produced at a constant rate because the half-value period of radium is very large. At the same time, the emanation is also disintegrating. The number of atoms of emanation which break up per second depends on the total number present; it is, in fact, always the same fraction of the number present.* When the amount of emanation in the tube is small, a small number of atoms disintegrate per second. But a definite amount of emanation is produced per second by the

* This is what is meant by the statement that the decay of radio-active matter follows an exponential law.

radium; hence, if the amount produced per second exceeds the amount which decays per second, the amount of emanation in the tube must increase. As soon as the amount of emanation increases, however, the amount which decays per second also increases. It follows, therefore, that when the number of atoms of emanation which disintegrate per second is equal to the number of radium atoms disintegrating per second, there can be no further increase in the amount of emanation in the sealed tube. We then say that we have the equilibrium amount of emanation. We may extend the same kind of reasoning to the rest of the radium products and we get that when radium and its subsequent products are in equilibrium, the same number of atoms of each substance disintegrate per second.

We have already said that radium emanation is a gas. It is, therefore, a relatively simple matter to separate it from the solid radium. If we do this and we start with emanation instead of radium in the sealed tube, we get a similar result. Only, since the emanation decays very much more rapidly than radium, we do not get a practically constant radiation as before, because the number of atoms disintegrating per second is decreasing rapidly all the time. It takes 3.85 days for the emanation to decay to one-half its original amount, whereas the decrease of a given quantity of radium in a lifetime is negligible.

It is evident that if we are after the γ-ray activity of the substances in the sealed tube, as far as the quality of the rays is concerned, it makes no difference at all whether we use radium or its emanation as the primary substance, because in either case the γ-rays are generated in the process of disintegration of Ra B, Ra C and Ra E. The only difference is that the amount of radiation remains practically constant in one case but diminishes in the other. Still, the rate of decrease is not too rapid for most purposes and therefore this convenient method of getting a source of γ-rays is very widely used. In our work the advantages derived from the use of radium emanation for the source of rays are many. At this point it is sufficient to mention two: (1) There is no danger of losing any radium accidentally because it is not handled at all. (2) The source of radiation can be arranged to satisfy our requirements. We can have it concentrated in a small volume or spread

out over a large surface at will. This could not be done very conveniently—in many cases it could not be done at all—if radium itself were used.

COLLECTION OF RADIUM EMANATION

Through the generosity of Dr. James Douglas, the hospital has at the present time about 2.8 grams of radium element and the amount is increasing at the rate of about 100 milligrams a month. The radium is in the form of radium bromid dissolved in water to which a small amount of hydrochloric acid has been added. The reason for keeping it in solution is to facilitate the escape of the emanation from the radium compound. The glass flask in which the solution is kept is sealed to a glass tube which in turn is sealed to the purifying apparatus, and the whole is kept as free from air as possible.

The radiations from radium and its products act on the water and the hydrochloric acid, and liberate hydrogen, oxygen and chlorine. Hence, when the emanation is first drawn off from the flask, it is mixed with these gases and with a large amount of water vapor. Besides, the radiations decompose also organic compounds such as the grease of stopcocks, and so other gases are always present. The volume of the emanation itself is extremely small, but owing to these by-products, the gases pumped out of the flask occupy a relatively large volume. In order to get a concentrated source of radiation it is necessary, therefore, to get rid of these impurities. There are two methods of accomplishing this result. Roughly speaking we may say that one consists in separating the extraneous gases from the emanation by means of different chemicals; while the other consists in separating the emanation from the residual gases by condensing it by means of liquid air. We employ the first method which in practice is simpler and very satisfactory for all our purposes. Using the purifying apparatus designed by Professor William Duane we can get the emanation two or three times more concentrated than we ordinarily need it.

After most of the objectionable gases have been removed by the chemicals in the purifying apparatus, by means of mercury pumps the emanation and the residual gas are displaced into a very fine capillary glass tube which has previously

been exhausted thoroughly. The portion of the capillary tube containing the emanation is sealed off with a small flame and from it several tubes of the required length are made. In doing this practically none of the emanation is lost because the pressure of the gases inside the tube is less than the pressure of the air outside, so that, as the glass tube is heated, it collapses and seals itself shut. The tubes we ordinarily use are less than $\frac{1}{2}$ mm. in outside diameter and from 12 to 20 mm. in length.

It has already been stated that radio-active processes are absolutely uncontrollable. It will be seen, therefore, that the total amount of emanation available at any time can never be greater than the equilibrium amount. In practice it is always less. With the amount of radium which we have, the efficiency of our purifying apparatus is about 95 per cent.; that is, every day we collect about 95 per cent. of the theoretical amount of emanation. As the emanation decays, the tubes become weaker and weaker until they are too weak to be used at all and must be discarded, although in the aggregate they contain an appreciable amount of emanation. Also, some tubes are lost, some are broken in handling, and other accidents may happen, so that the total amount of emanation actually available every day is about 85 to 90 per cent. of the equilibrium amount. If the radium in equilibrium with its products were used for the treatments we would have the maximum amount available all the time. However, this advantage is entirely obscured by the advantages accruing from the use of the emanation as a source of radiation.

The measurement of quantities of radium emanation is always based on the electrical effects of its radiation or the radiations from its subsequent products. All three types of radiation are capable of ionizing a gas. If the ionized gas is between two insulated metallic plates (ionization chamber) and a suitable voltage is applied to them, there will be a flow of current which can be detected by various means. From a knowledge of the magnitude of this current in comparison to the magnitude of the current produced when a known amount of emanation is used, it is a simple matter to calculate the unknown amount of emanation. By such an electrical method very minute quantities of emanation can be measured accurately.

We have already seen that the amount of emanation in equilibrium with a given quantity of radium element is perfectly definite. Use has been made of this fact to define the unit of emanation. At the Brussels Congress in 1910 it was decided to honor M. and Mme. Curie by naming the unit of emanation after them. Accordingly the curie was defined as the quantity of emanation in equilibrium with one gram of radium element. Since in practice we are always dealing with small quantities of emanation, for a practical unit it is convenient to use the millicurie (equal to 1/1000 of a curie). The volume occupied by one curie of radium emanation at standard pressure and temperature is about 0.6 cubic millimeter, according to theory and experiment. Although radium emanation is the heaviest gas known, the weight of one curie of emanation is only 5.7×10^{-6} gram.

The dimensions of the longest glass tubes containing the emanation which we ordinarily use are: Length, 2 cm., outside diameter less than 0.05 cm. Into a tube of this size we can put as much as 200 millicuries of emanation but we never need more than 60 millicuries per tube, and, as a rule, the tubes contain from 30 to 45 m.c. when first made. It is quite evident now that it would be impossible to use such small sources of intense radiation if radium itself had to be sealed in the tubes. And still they are required for some treatments. The objection that the radio-activity of the emanation tubes decreases with time, is not valid in these cases because the tubes are never applied for more than a few hours at a time and the decay of emanation during this short interval is almost negligible. For longer exposures we can calculate mathematically the average value for any given interval.

For the sake of brevity, from this point on we shall call the small glass tubes containing the emanation simply "emanation tubes."

RADIO-ACTIVE DEPOSIT

We have already stated that radium emanation is a gas and that its first disintegration product, Ra A, is a solid. An atom of Ra A is produced when an atom of emanation breaks up with the consequent ejection of an α particle traveling at high

velocity. The law of the conservation of momentum requires that the atom of Ra A and the α particle travel in opposite directions and with velocities that are inversely proportional to their masses. (This is analogous to the recoil of a gun when it is fired.) The "recoil" atom of Ra A has a mass about 55 times larger than the α particle and therefore its velocity will be about 55 times smaller. It is, nevertheless, quite high and if the atom is not hindered in its flight it will embed itself in the walls of the vessel containing the emanation. But if there is much gas in the vessel, the recoil atom soon loses its velocity on account of the impacts which it makes with the molecules in its path. Thus, in air at atmospheric pressure, the recoil atom travels a distance of about 0.1 mm. before it comes to rest. Then it slowly diffuses towards the walls of the vessel and finally attaches itself to them. Meanwhile it may be time for it to explode, release an α particle, and become Ra B. Without going into further details it is evident that any surface which is exposed to the emanation will be coated with a very thin film of Ra A and its subsequent products. This constitutes the active deposit. The coating is very thin indeed and is invisible; the amount of radio-active matter deposited from the emanation being exceedingly minute. The active deposit is uniformly distributed over the surface which has been exposed to the emanation.

If we want to use the active deposit as a source of radiation we can collect it in the following way: A glass tube is lined on the inside with lead foil and is sealed to the emanation purifying apparatus so that the air can be pumped out and concentrated emanation can be introduced into it. After being exposed to the emanation for three or four hours the lead foil will be strongly radio-active. When equilibrium conditions have been reached, there is always a definite amount of active deposit associated with a given quantity of emanation but it is distributed over all surfaces exposed to the emanation. If we want to collect most of the active deposit on a wire the best way is to keep the wire charged to a high negative potential while it is exposed to the emanation. The recoil atoms are positively charged because the ejection of an α particle carrying two positive charges is accompanied by the ejection of probably three slow speed negative electrons, known as secondary delta

(δ) rays. Under suitable conditions, then, they will travel to the negatively charged wire.

A glance at the table given on page 20 will show that Ra A, B, C disintegrate very rapidly, while Ra D, E, F disintegrate much more slowly. The former group constitute the active deposit of rapid change and the latter the active deposit of slow change. The former has greater practical importance. Using the first method of collection described above, we can get a strong radiation of uniform intensity from a piece of lead foil which, for instance, can be applied under the eyelid.

The decay of the active deposit depends on a number of conditions. For a piece of lead foil which has been exposed to a constant amount of emanation for several hours the α-ray activity drops to half value in about 15 minutes and the γ-ray activity is reduced to half value in one hour. After 24 hours the activity has fallen to a very small fraction of its initial value.

PROPERTIES OF THE RADIATIONS

All three types of radiation (α, β and γ) are capable of ionizing a gas, affecting a photographic plate and causing certain substances to fluoresce. This is remarkable in view of the fact that they are so widely different in nature. But the reason for the similarity of behavior may be traced to their common property of breaking up an atom which lies in their path. They all can knock off electrons from the atoms. If these electrons are responsible for the effects attributed to the different radiations, there is no apparent reason for expecting any fundamental difference in their behavior.

It is pretty well established now that the ionizing action of the rays is due to the secondary corpuscular rays they produce in the matter they traverse. This is identical to the behavior of x-rays. As a matter of fact the distinction between x and γ radiation is purely arbitrary. The hardest γ-rays are much more penetrating than ordinary x-rays and their behavior varies accordingly, but they are essentially the same. β-rays are analogous to cathode rays. Both consist of swiftly moving electrons but the speed of the swiftest β particles is much higher than that of the cathode particles. The α-rays are analogous to

the canal rays of a discharge tube. Hence it will be seen that all three types of radiation given off spontaneously by radio-active substances can be produced artificially. Their penetrating power, however, is much smaller than that of the spontaneous radiations.

The swiftly moving charged particles (α and β) possess energy by virtue of their motion. The γ-rays also possess energy. Hence a radio-active substance is always radiating energy into space. A gram of radium in equilibrium with its products gives off energy at the rate of about 110 calories per hour or, roughly speaking, is capable of melting its own weight of ice in less than an hour. When it is considered how minute is the amount of radium which disintegrates per hour, it is seen how enormous must be the amount of energy stored in the atom.

The energy radiated is not equally divided among the three types of radiation. By far the largest part is carried by the α particles. The relative ionization is also very different. When the source of radiation is a layer of a radium compound so thin that we can neglect the absorption of the rays by the active material itself, the relative ionization between charged plates 5 cm. apart, due to the α-, β- and γ-rays is of the order of 10,000, 100 and 1 respectively. On the other hand the γ-rays are from 10 to 100 times more penetrating than the β-rays and the latter are about 100 times more penetrating than the α-rays. A sheet of ordinary writing paper, or a thickness of 0.006 cm. of aluminium, is sufficient to absorb completely all the α-rays. A thickness of 10 mm. of aluminium or 2 mm. of lead is required for the absorption of practically all the β-rays. A screen of this sort is enough to absorb most of the soft γ-radiation also, but it has little effect on the most penetrating γ-rays.

For any one type of radiation the absorption is approximately proportional to the density of the absorbing substance. In the case of lead, mercury and other heavy substances, however, the absorption is relatively greater than for light substances. That is, if lead is ten times as dense as another substance, a thickness of lead of 1 mm. will be more effective in stopping the radiation than 10 mm. of the other substance.

No one of the three kinds of radiation emitted by an emana-

tion tube is homogeneous. The α-rays are usually completely absorbed by the glass of the tube. But tubes with very thin walls can be made and then the α particles can escape. In this case it is found that the velocity of all α particles is not the same. In fact it is known that the initial velocity of all the α particles from any one substance is the same, but is different for different substances. The velocities range from 1.3×10^9 to 1.96×10^9 cm. per second. The β-rays are little absorbed by the glass walls of the ordinary emanation tubes. They also consist of homogeneous beams with characteristic velocities on a background of rays having all sorts of velocity. But the complexity in this case is greater than in the case of the α-rays. The swiftest β particles travel almost as fast as light.

It has already been stated that γ-rays are nothing but x-rays of great penetrating power. The presence of the γ-rays from 50 millicuries of emanation can be easily detected electrically behind a lead screen 25 cm. thick. It is now well known that the γ radiation is also complex. It consists of a general radiation of all wave-lengths between wide limits and of definite monochromatic beams. In this respect the similarity between γ-rays and x-rays is very striking. The monochromatic beams of γ-rays correspond to the characteristic x radiations of different metals. In fact some of these homogeneous beams have already been identified as the K and L radiations of the particular substance from which they originate. As in the case of x-rays, it is possible to analyze γ-rays by means of crystals. The most penetrating γ-rays are emitted by Ra C.

ABSORPTION OF RADIATIONS

The absorption of β-rays by matter follows approximately an exponential law. This means that equal thicknesses of the same material absorb the same fraction of the incident radiation. Thus if a hypothetical beam of β-rays has its intensity reduced to one-half its original value after passing through 1 mm. of aluminium, it will be cut down to $\frac{1}{4}$ of its initial strength by 2 mm. of aluminium. The beam of β-rays is scattered considerably in passing through matter. Some β particles are deviated so much from their paths that they emerge

again on the side of incidence of the original beam. The absorption of β-rays by equal thicknesses of different substances in general increases as the atomic weight of the substance increases, but there is no simple relation between the two. It is independent of the chemical combination of the atoms. Thus the absorption is the same whether the beam passes through a certain thickness of silver nitrate solution and then through a thickness of hydrochloric acid, or it passes through a mixture of the two solutions, even though silver chlorid has been precipitated in the process. It is evident then that the absorption of β-rays is an atomic phenomenon. This is also the case for all types of radiation emitted by radio-active substances as well as for cathode rays and x-rays. The intensity of the β radiation of Ra C is cut down to one-half its initial value after traversing 170 cm. of air at atmospheric pressure and room temperature. The corresponding air thickness for the β-rays from a thin film of Ra B + C is about 55 cm.

Quite similar to the absorption of β-rays is the absorption of γ-rays. The variation of the absorption with thickness of material varies somewhat with the experimental method employed in determining it. But if the rays are allowed to pass through a few millimeters of lead first, the absorption follows closely an exponential law. For the first two or three millimeters of lead it is considerably higher than for larger thicknesses. This is due to the fact that the soft rays are easily absorbed by small thicknesses of material. When lead is used as the absorbing substance this effect is very marked. The emerging beam of γ-rays is harder (more penetrating) than the original beam, because most of the soft rays are removed by a few millimeters of lead. An idea of the great penetrating power of the γ-rays of radium can be gotten from the fact that, after passing through about 5 cm. of lead, it takes an additional thickness of 1.4 cm. to cut down the intensity to half value. If air at ordinary temperature and pressure is used as the absorber, a distance of 115 meters (about 345 feet) must be traversed by the rays before their intensity is reduced to half its original value. It takes a thickness of 760 meters of air to cut down the intensity to 1/100. In this connection it should be remembered that in any case the intensity of the γ radiation from a small source decreases as the square of the

distance and the decrease due to absorption is additional to this.

The absorption of γ-rays by different substances does not increase regularly with the atomic weight. The relative absorption is least for elements of density between 2.6 and 8.8 and greatest for heavy elements like mercury and lead. For instance, if 11.4 and 7.6 are the densities of lead and iron respectively, $\left(\frac{100}{11.4} =\right)$ 8.77 mm. of lead absorb more than $\left(\frac{100}{7.6} =\right)$ 13.6 mm. of iron. Of course if the absorption were proportional to the density it should be the same in both cases.

SECONDARY RADIATIONS

Just as cathode rays impinging on a target produce x-rays, so β-rays striking any substance generate a type of x radiation, which, however, is more penetrating than ordinary x-rays owing to the greater speed of the electrons of the β-rays. There is really no difference in the nature of the two phenomena.

The intensity and penetrating power of the secondary γ-rays increases rapidly with the atomic weight of the radiator. The quantity of the radiation from any one substance depends on the thickness of the radiator and varies directly as the amount of β radiation absorbed by it. The intensity is greater on the side of emergence than on the side of incidence of the primary beam.

There is no evidence that β-rays induce a secondary corpuscular radiation. But they are scattered through wide angles in passing through matter and a considerable percentage is "reflected" back on the side of incidence.

The γ-rays, as in the case of x-rays, also produce secondary radiation when they impinge on matter. In the first place a portion of the incident radiation is scattered without change of quality. At the same time a corpuscular secondary radiation of the β-ray type and a secondary radiation of the γ-ray type are set up. Both types of secondary rays are much more penetrating than the corresponding secondary rays produced by x-rays.

The penetrating power of the secondary β-rays is about the same as the primary β-rays emitted by the source of γ-rays. The secondary β radiation from heavy elements like lead is slightly more penetrating than that from light elements like aluminium. The amount of β radiation from different substances on the side of incidence increases with the atomic weight. On the emergence side of thick plates it is a minimum for substances of atomic weight close to that of zinc and larger for substances of lower or higher atomic weight. The intensity is much greater on the side of emergence than on the side of incidence of the primary γ-rays for substances of low atomic weight. For heavy metals the difference is small.

At present our knowledge of the secondary γ radiation produced by γ-rays is very limited. But we know that a general secondary γ radiation and a characteristic γ radiation are both set up. In addition the original beam of γ-rays is scattered in all directions but to a much smaller extent than a beam of x-rays.

If we examine the distribution of the γ radiation around a metallic plate through which a beam of γ-rays passes, we find that the intensity is greatest in the direction of the original beam and decreases rapidly as we go towards the plane of the plate. In this direction (*i.e.*, at right angles to the original beam) and on the side of incidence, the intensity is much smaller than in a forward direction. Besides, the quality of the radiation is also different: the γ-rays becoming softer as the angle they make with the transmitted beam increases.

The study of the variation of the intensity with the thickness of the radiator reveals that for angular positions near the transmitted beam, the intensity at first increases with the thickness of the radiator and then gradually decreases owing to the excessive absorption of the original beam by the radiator. Florance has found that using screens of different materials, of which the thickness multiplied by the density is constant, the amount of secondary radiation is greater for carbon and iron than for lead.

Although of little importance to us, it should be mentioned that α-rays also produce secondary rays when they strike matter. The corpuscular rays which they set free are nothing but slow speed β particles and are called delta (δ) rays. An α particle

can liberate several δ particles. Chadwick has obtained evidence tending to show that α-rays are able to excite γ-rays when they fall on ordinary matter.

CHEMICAL ACTIONS

All three types of radiation, but especially the α-rays, produce marked chemical effects in many substances. These effects are undoubtedly attributable to the ionization produced in all kinds of matter by the radiations. In some cases complex molecules are dissociated, in others complex molecules are built up.

From oxygen ozone is produced mainly by the action of α particles. Metals near a source of intense α radiation are, therefore, readily oxidized. Under the action of a strong α radiation paraffin and vaseline become hard and infusible. The α-rays of radium have a marked effect on the coagulation of globulin. Organic matter is in general easily decomposed by the radiations. Thus carbon dioxid is produced from the grease of stop-cocks; a large volume of gas is produced from paraffin. Radium bromid exposed to the air gives off bromine and is ultimately turned into carbonate. A solution of radium chlorid attacks platinum, probably owing to the production of nascent chlorine. Many substances are colored by the radiations. Soda glass is colored violet, manganese glass turns brown. Quartz and glass become more brittle by continued exposure to the radiations. White phosphorus is changed to the red variety by the action of the β-rays. The radiations produce a precipitate of calomel in the presence of oxalic acid. Silver nitrate is reduced to metallic silver. A solution of iodoform in chloroform turns purple owing to the liberation of iodin due mainly to the β-rays. Water is decomposed into oxygen and hydrogen by the action of all three types of radiation. One gram of radium in solution produces about 13 cubic centimeters of mixed gases per day. An excess of hydrogen is always produced probably owing to the decomposition of water by the β-rays in the abnormal way represented by the equation:

$$2H_2O = H_2O_2 + H_2$$

In the course of time paper and fabrics are reduced to powder.

The action of radium emanation on certain gases has been studied carefully. It has been found that carbon dioxid is transformed into carbon, carbon monoxid into carbon and oxygen; ammonia into nitrogen and hydrogen; hydrochloric acid into hydrogen and chlorine. But it has also been found that gases recombine under the action of the radiations. Thus nitrogen and hydrogen form ammonia; hydrogen and chlorine form hydrochloric acid.

THERAPEUTIC USES

From what has been said in the preceding pages it is evident that we have in radium an agent which is capable, through the action of its radiations on the atom, to affect all matter to an extent hitherto unsuspected. The changes produced in organic compounds are most marked owing to the complexity of their molecules and hence the greater ease of rearrangement of the atoms. It might be anticipated, therefore, that the radiations would have a marked influence on the living cell. This has been found to be the case. But it would not be expected, from *a priori* considerations, that the behavior of cancer cells should differ from that of healthy cells, under the action of the radiations, in the manner that it does. It is found that in general cancer tissue is more susceptible to the radiations than healthy tissue. That is, under suitable conditions, a complete retrogression of a tumor will take place without bad effects to the neighborhing healthy tissue. In this respect we may say that the radiations have a selective action on the tumor tissue. Perhaps it would be better to call it a differential action because both the tumor and the flesh are affected and it is the extent of the effect that is different.

The successful treatment of cancer by radium is based on this fact. However, it is one thing to know that the radiations have a differential effect on cancer tissue, and an entirely different thing to turn it to account successfully. The practical difficulties are very numerous. In the first place we are dealing with living organisms whose life may be influenced by many factors. It is not easy, therefore, to determine just to what extent the observed change is due to the radiations or to

other causes. This difficulty will be better appreciated if we remember that in some cases there is no noticeable change in the lesion for a period of several weeks or even months after the exposure to penetrating γ-rays. Then the determination of the proper dose (with the many factors which it involves as will be seen later) for each kind of lesion and each patient is beset with great difficulties. However, gratifying results have already been obtained and it is reasonable to expect better results as our knowledge of the action of the radiation on the living cell increases and the proper technique is acquired by long experience.

APPLICATORS

The most important requirements which a good applicator must fulfill are: (1) Its shape must be such as to be best adapted to the treatment of at least one kind of lesion. (2) It must be made of such material as will give the required filtering without introducing objectionable soft secondary radiations.

When we use radium emanation as the source of radiation there are no limitations to the number of *different* applicators we may employ because it is a relatively simple matter to transfer the emanation tubes from one to the other according to the requirements of any particular case. Also the very small size of the emanation tubes makes it possible to have very small applicators of any shape we desire.

By filtering is meant the interception of the less penetrating radiations by means of proper screens. The necessary filter for any particular case is determined from our previous experience with similar cases. It is probable that the physiological effect produced by equal amounts of soft and hard γ-rays (as measured by ionization) are somewhat different. However the case may be, in treating deep-seated tumors we want to use the most penetrating rays in order that their intensity shall not be cut down unduly by the intervening flesh which would necessarily be affected disastrously. In such cases it is necessary, therefore, to interpose between the emanation tubes and the skin a thickness of material sufficient to absorb all but the most penetrating γ-rays.

When we try to obtain this result in practice we encounter some difficulties. We have already seen that the passage of γ-rays through matter gives rise to two kinds of secondary radiation. As the secondary radiations are always less penetrating than the parent rays, they always tend to defeat the purpose of the filter. It follows that the best we can do is to minimize the deleterious effects of the secondary rays by proper choice of absorbing materials and their juxtaposition. The denser the absorbing material the more penetrating is the characteristic secondary γ-radiation but the more copious is the emission of secondary β-rays. The secondary radiations from a thin layer of a light material are practically negligible. Therefore the best arrangement seems to be to use a heavy metal like platinum or lead to do the filtering and then cover it with a thin layer of aluminium to remove most of the soft secondary rays. Rubber, leather, wet gauze, etc., may also be used.

The applicators which we use are shown in the photograph on p. 70. They have been devised by Dr. Janeway in accordance with the requirements of the different types of treatment. A description of the applicators and their uses will be found on p. 69 *et seq.*

RADIATION FROM TYPICAL APPLICATORS

It is very important to know how the intensity of radiation varies with the distance from an applicator. This can be done mathematically by making a few simple and justifiable assumptions. If we are after relative values only, we need not define a unit of radiation intensity. But if we wish to specify the doses in terms of the intensity of the radiation we must first define a suitable unit. If we attempt to do this we are at once confronted by some difficulties. In the first place, if the walls of the emanation tubes are sufficiently thin, the radiation consists of three different types (α, β and γ), each of which is nonhomogeneous. The effects produced vary with the speed of the particles in the case of the corpuscular rays and with the wave-length in the case of the γ-rays. Besides we have to consider on what particular action of the rays we are to base our definition.

In the therapeutic applications of the radiations we are concerned with the physiological effects produced by them. But these effects depend on so many uncertain factors that it is impossible to make use of them in defining the unit of radiation intensity. We can, however, base our definition on some one physical property possessed by all three types of radiation, which is mainly responsible for the physiological effects. Ionization seems to be the best criterion for the definition of a unit. All three types of radiation are capable of ionizing a substance and, besides, ionization probably plays the most important part in the physiological effects.

Having decided to base our definition on ionization, we still have to select the method of measuring the intensity of ionization. Other things being equal, the number of ions produced per second per unit volume depends on the substance which is ionized. For our purposes we should measure the ionization produced in the tissues, but it is practically impossible to do so. On the other hand, it is a very simple matter to measure it in a gas. The use of a gaseous medium has the added advantage that there is no undue decrease of intensity due to the absorption of β- and γ-rays by the gas in a small ionization chamber. The simplest method is, of course, to use air at atmospheric pressure and room temperature.

The next thing to consider is the apparatus to be used for measuring the ionization in air. An electroscope is very suitable for this purpose. But, as the results obtained depend to a considerable extent on the kind of electroscope employed and on the relative position of the source of radiation and the electroscope, it is necessary to specify very fully the experimental conditions. In our work we need not consider the α-rays at all because the walls of the emanation tube are usually thick enough to intercept them completely. But as we want to determine the ionization produced by an emanation tube with and without different screens the walls of the electroscope should be thin enough to permit the passage of β-rays without undue absorption.

Let us take as the unit of intensity of radiation the intensity at a distance of 1 cm. from 1 curie of emanation concentrated in a very small sphere of the proper thickness to intercept all the alpha particles without appreciably affecting the β- and

γ-rays. The intensity is to be measured by the ionization produced in air at atmospheric pressure (760 mm. of mercury) and room temperature (16° C.), inside an aluminium electroscope whose two sides directly in the path of the rays are 0.0116 cm. in thickness and have an area of 20 sq. cm. That is, the intensity of radiation, as thus defined, is measured by the number of ions produced per second per unit volume of air, under certain definite conditions. This definition differs materially from the definition of radiation intensity used in physics. There the intensity is measured by the flow of energy per unit area perpendicular to the line of propagation. Here we are considering only the energy which is absorbed in the production of ions. We may call this unit the "radion," the word being made up from the roots of the words *rad*-iation and *ion*-ization, which are the most important factors in the definition.

It will be noticed that since the intensity of radiation is measured by the intensity of ionization produced at the particular point under consideration, it makes no difference what the proportion of β- and γ-rays is. Therefore, the mere statement that the intensity at a certain point is n radions does not tell us anything about the nature of the radiation. However, when the term is used in connection with treatments and the filter is specified, we can get a definite idea of the quality and quantity of radiation employed.

If we have 100 millicuries of emanation in a glass bulb 1 mm. in diameter, the intensity of radiation at a distance of 1 cm. is 100 milliradions; at a distance of 2 cm. it is $\frac{100}{4} = 25$ milliradions; at a distance of 5 cm. it is $\frac{100}{25} = 4$, etc.—the intensity varying inversely as the square of the distance. But if we have a source which is large in comparison to the distances at which we wish to determine the intensity, we cannot assume the inverse square law to hold. However, for any distributed source we can calculate the intensity at any point (at least theoretically) by the mathematical process of integration.

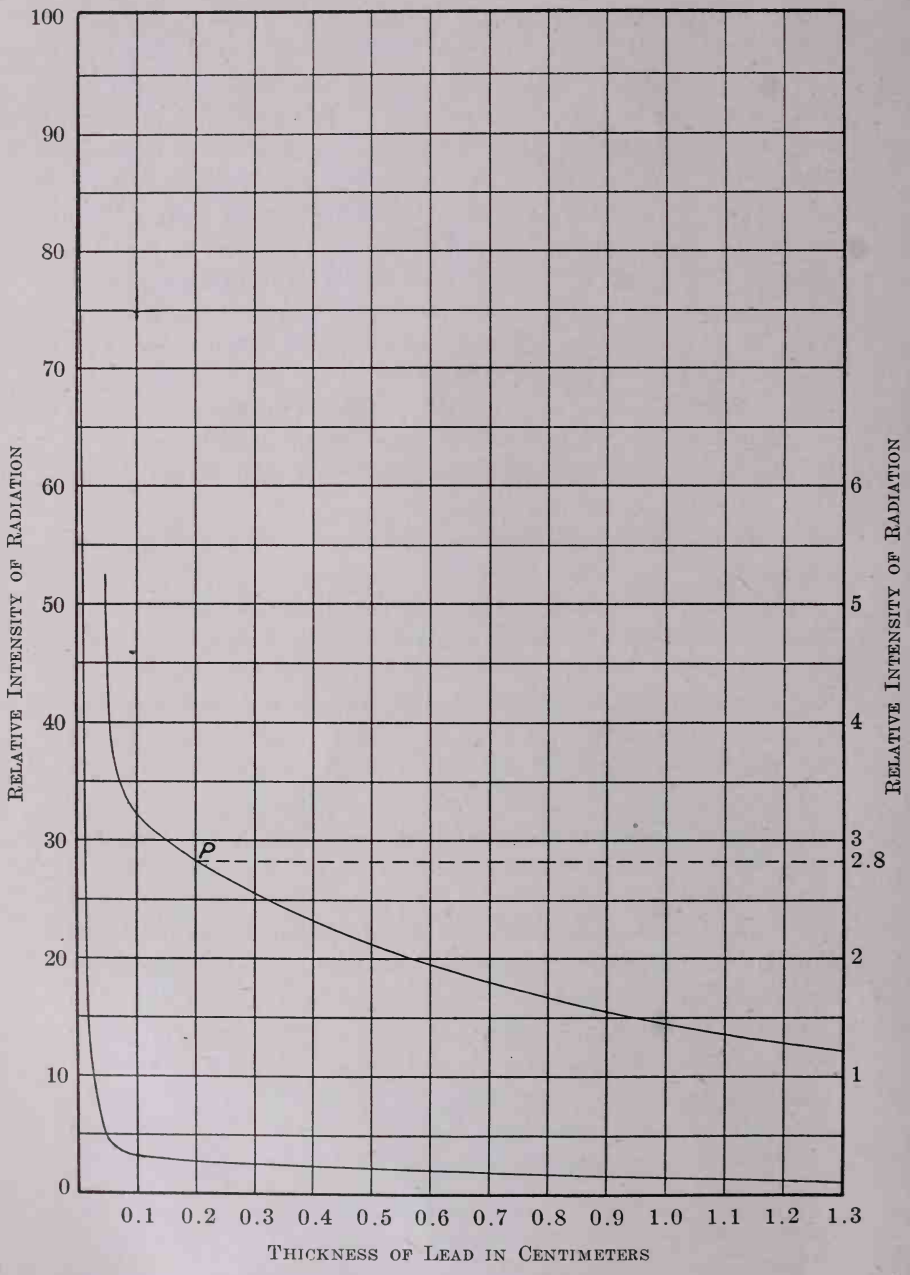
Let us determine now the absorption of the radiation by different thicknesses of lead. If we put a small emanation tube

at a distance of 20 cm. from the aluminium electroscope mentioned above * and measure the ionization produced by the rays after they pass through different thicknesses of lead placed in front of the tube, we get the results shown graphically in Fig. 1. Owing to the peculiar shape of this curve, it is necessary to draw its lower part to an enlarged scale in order that the values may be read with reasonable accuracy. In Fig. 1 the upper curve is an enlarged reproduction of part of the lower one. The scale at the left refers to the lower curve; the scale at the right, which is 10 times as big as the former, refers to the upper curve. These remarks apply also to the curves in Figs. 2, 3, and 4. The intensity of radiation when there is no lead in the path of the rays is assumed for convenience to be 100. All other values are relative to this. Thus when the rays go through 0.2 cm. of lead the intensity is 2.8 as indicated by P on the curve. That is, the interposition of a lead plate 0.2 cm. thick between the emanation and the electroscope has decreased the intensity of radiation from 100 to 2.8. Similarly for other thicknesses.

The curve shows that most of the radiation is absorbed by a small thickness of lead—a thickness of 0.07 cm. being sufficient to reduce the intensity to about 3.5. The decrease beyond 0.2 cm., however, is small. It will be remembered that the relative ionization produced by α-, β- and γ-rays is of the order of 10,000, 100 and 1 respectively (see p. 28). The α-rays are entirely absorbed by the glass of the emanation tube so they do not enter into consideration here. The β-rays, for the most part, are absorbed by a small thickness of lead and this accounts for the rapid drop of the first part of the curve. A thickness of 0.2 cm. of lead is sufficient to intercept practically all the β-particles and most of the soft γ-radiation. Beyond this point the intensity decreases much more slowly, showing that the radiation which has traversed 0.2 cm. of lead is very penetrating. After passing through 0.2 cm. of lead an additional thickness of 0.8 cm. is necessary to cut down the intensity to half value. But we have seen that the corresponding thickness for the most penetrating γ-rays is 1.4 cm., therefore an appre-

* The other experimental conditions, although important from a physical standpoint, are irrelevant to the present discussion and need not be given here.

FIG. 1.—CURVES SHOWING THE ABSORPTION OF THE RADIATIONS FROM AN EMANATION TUBE BY DIFFERENT THICKNESSES OF LEAD



ciable fraction of the soft γ-rays is still present. However, a screen of 0.2 or 0.3 cm. of lead, or its equivalent, is all that is required for most treatments.

The curve shows very clearly the necessity of using heavy screens in treating deep-seated tumors. If we use the bare tubes most of the radiation is absorbed by superficial layers of tissue and only a small amount reaches the tumor. The result is that the superficial tissues are destroyed before the tumor has been affected appreciably. But if we use penetrating γ-rays (and put the applicator at the proper distance, as we shall see later) there is no very great disparity between the radiation absorbed by the tumor and that absorbed by the intervening flesh. As cancer cells are more susceptible to the rays than normal cells, the effect on the tumor may easily be greater than on the healthy tissue.

Now let us consider the variation of intensity with distance for sources of different shape. The curves in Fig. 2 show the variation of the intensity of radiation from a bare emanation tube 1.8 cm. in length containing 100 m.c., as we move along a line perpendicular to the tube at its middle point. This curve was plotted from values calculated mathematically, neglecting the absorption of the air, which for these short distances is very small. If the same emanation tube is enclosed in a lead capsule 2 mm. thick the intensity varies as shown by the curve in Fig. 3.

The dotted curve in Fig. 3 shows the variation with distance of the radiation from a flat applicator one inch square containing 100 m.c. of emanation evenly distributed among 7 parallel holes covering an area of $1.8 \times 2 = 3.6$ sq. cm., the filter being 2 mm. of lead for rays perpendicular to the surface of the applicator. The figures along the horizontal axis represent distances measured from the center of the emanation tube in the middle hole along a line perpendicular to the surface of the applicator. The same curve plotted to a larger scale is shown in Fig. 4.

The curves in Figs. 2 and 3 show how rapidly the intensity of radiation decreases with the distance from the applicator. The decrease is most rapid in the case of the bare emanation tube and least rapid in the case of the flat applicator. Beyond a distance of a few centimeters from the applicator the relative

FIG. 2.—CURVES SHOWING THE VARIATION WITH DISTANCE OF THE INTENSITY OF RADIATION FROM A BARE EMANATION TUBE

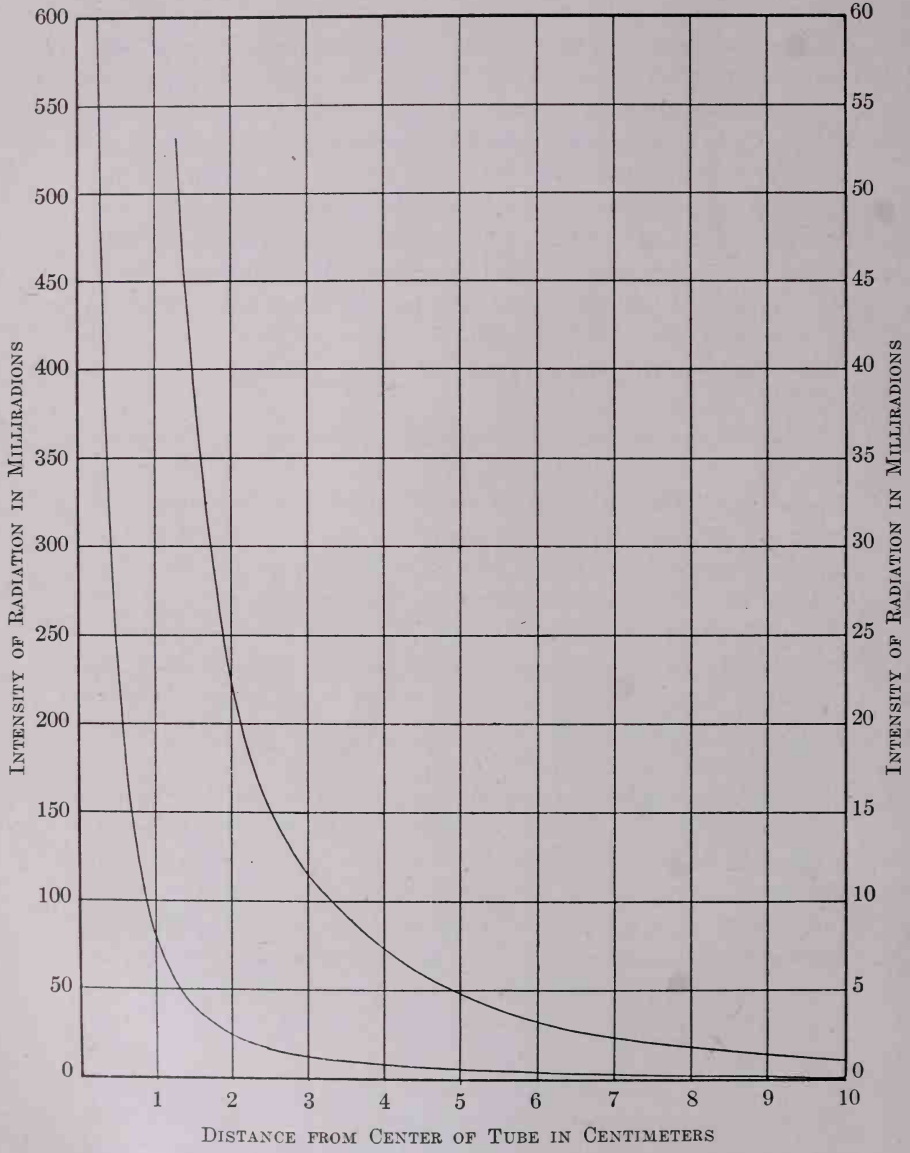
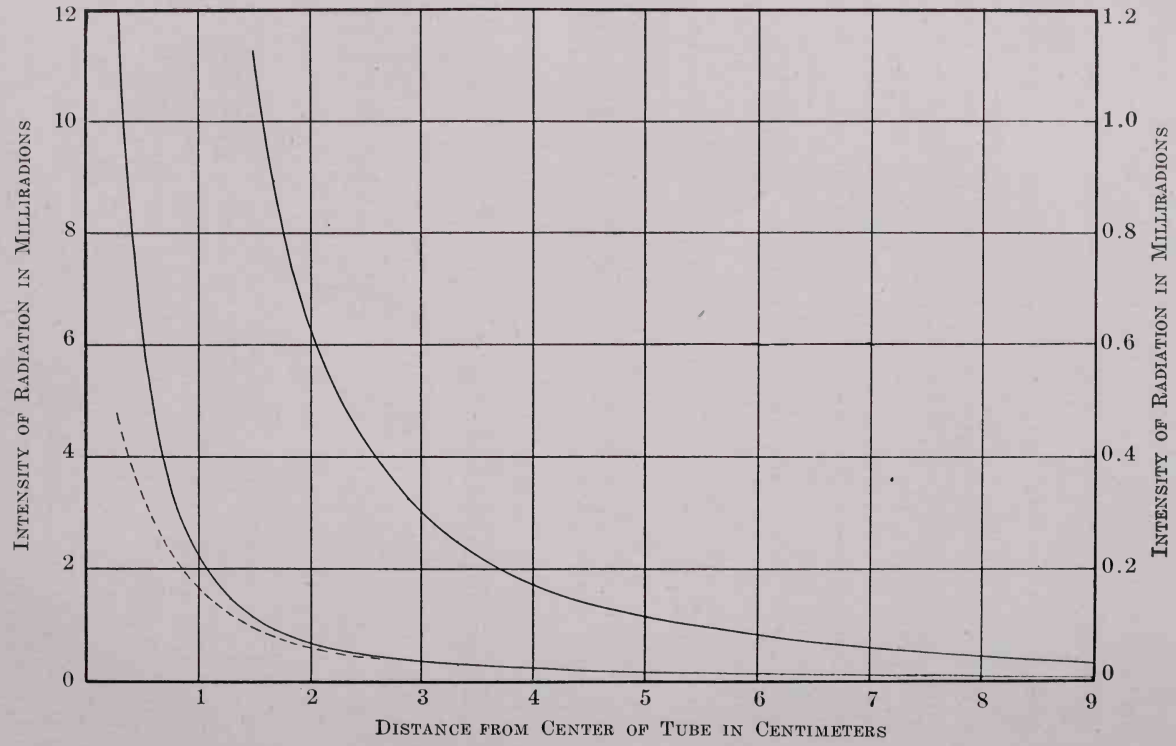


FIG. 3.—CURVES SHOWING THE VARIATION WITH DISTANCE OF THE INTENSITY OF RADIATION FROM AN EMANATION TUBE SURROUNDED BY 2 MM. OF LEAD



decrease of the intensity is practically the same for all three applicators. This is shown clearly by the figures in Table II.

TABLE II*

Points (1 cm. Dist. Apart)	Bare Tube			Lead Tube			Lead Flat Appl.		
	Intensity at		Ratio $\frac{Im}{In}$	Intensity at		Ratio $\frac{Im}{In}$	Intensity at		Ratio $\frac{Im}{In}$
	1st pt. Im	2nd pt. In		1st pt. Im	2nd pt. In		1st pt. Im	2nd pt. In	
0– 1	502.	54.0	9.30	12.2	1.45	8.42	4.67	1.176	3.97
1– 2	54.0	18.4	2.93	1.45	0.50	2.90	1.176	0.470	2.50
2– 3	18.4	9.2	2.00	0.50	0.254	1.97	0.470	0.250	1.88
3– 4	9.2	5.40	1.70	0.254	0.151	1.68	0.250	0.151	1.65
4– 5	5.40	3.55	1.52	0.151	0.100	1.51	0.151	0.100	1.51
5– 6	3.55	2.50	1.42	0.100	0.071	1.41	0.100	0.071	1.41
6– 7	2.50	1.90	1.32	0.071	0.0537	1.32	0.071	0.0537	1.32
7– 8	1.90	1.50	1.27	0.0537	0.0423	1.27	0.0537	0.0423	1.27
8– 9	1.50	1.20	1.25	0.0423	0.0388	1.25	0.0423	0.0338	1.25
9–10	1.20	0.97	1.24	0.0388	0.0272	1.24	0.0338	0.0272	1.24

Point 0 is taken at the surface of the lead tube and flat applicator and corresponds to a distance of 0.28 cm. from the center of the emanation tube. The ratio of the intensities at two consecutive points one centimeter apart ($\frac{Im}{In}$) is given in the third column for each applicator. It will be seen that for points near the source of radiation it is greatest in the case of the bare emanation tube and smallest in the case of the flat applicator. For distances greater than a few centimeters the ratios are the same for the three applicators. In every case the ratio decreases as the distance from the applicator increases.

This is of very great importance in the treatment of deep-seated tumors. It is evident that the farther the source of radiation is from the tumor the more uniform will be the radiation throughout the volume which comes under the influence of the rays. Hence the superficial layers of tissue will receive proportionately less radiation the farther we place the applicator. If we take account of the absorption in the tissues the difference between the radiation received by the skin and that received by the tumor is very great in the case of the unscreened emanation tube, because most of the radiation is then absorbed by

* These figures were obtained from smooth curves plotted to a large scale.

a small thickness of tissue. In the case of the lead tube and flat applicator, on the other hand, the decrease of intensity of radiation due to absorption in the tissue is small because the radiation which passes through 2 mm. of lead is very penetrating.

From the curve in Fig. 2 we see that the intensity of radiation at a distance of 1 cm. from the bare emanation tube is 82 milliradions. If the emanation were concentrated at a point the intensity would vary inversely as the square of the distance and the value at a distance of 1 cm. would be $\frac{100}{1^2} = 100$ milliradions. It is less in the case of the distributed source because the radiation from every point of the source, except the middle point, has to travel through a longer distance than 1 cm. At a distance of 10 cm. the intensity is practically $1 \left(= \frac{100}{10^2}\right)$ because then the distance is large with respect to the dimensions of the source and the inverse square law is applicable.

The decrease of intensity of radiation with distance is not so rapid in the case of the lead flat applicator as in the case of the bare emanation tube because for points near the applicator the rays have to traverse a larger thickness of lead than for points far away. The effect is more marked the more widely distributed is the source. This is shown very clearly by the figures in Table II. Both the lead tube and flat applicator, for which the figures are given, contain 100 m.c. of emanation, but the intensity at the surface of the applicator is 12.2 units in the case of the lead tube and only 4.67 units in the case of the flat applicator. At a distance of 1 cm. the intensities are 1.45 and 1.18 units respectively. As the distance increases the two values come nearer and nearer together until at a distance of 4 or 5 cm. they practically coincide. This shows the importance of distributing the source of radiation over a large area when we want to treat big, deep-seated tumors. The immediate result being that the source need not be placed so far away in order to obtain the same (and even better) distribution of the radiation throughout the region we wish to affect. It is in such cases that we use the "pack" of 12 flat applicators shown in Fig. 15 (p. 75).

It was hoped that we could include in this report the intensity-distance curves for such an applicator. But the calculations involved are long and tedious and they cannot be completed in time for publication.*

"DOSAGE"

In connection with the therapeutic uses of radium it is of the greatest importance to specify the exact conditions under which treatments are made. The reasons are obvious, for it is necessary in the first place to ascertain the conditions under which the most beneficial effects are obtained, and then it must be possible for any one to duplicate the treatments at any time and place.

There are many factors which play important parts in the treatments and all should be considered carefully in determining the proper dose for any particular case. The physiological effect of the radiation must depend largely, but not entirely, on the total ionization produced during the treatment per unit volume of tumor, which is substantially a measure of the energy absorbed. It is evident then that the *intensity* of radiation at the point we want to effect and the time of exposure are equally important. But we can produce the same total ionization by a small intensity of radiation and a long exposure or vice versa, and the question is whether it makes any difference, physiologically, which method we use. For small variations it makes no appreciable difference if the time of exposure is increased in the same proportion that the intensity of radiation is decreased or vice versa. But if we increase the intensity 100 times and decrease the time 100 times we cannot expect to obtain the same result as before. Apparently, then, there is an optimum intensity of radiation coupled with a definite time of exposure, but unfortunately the relation between the two varies with the nature of the tumor, etc., and cannot be determined except by experience. Besides the physiological effect may also vary with the quality of the radiation. Certainly other things being equal, the softer the radiation the more localized will be the effect, and the harder the radiation the larger will be the volume of tissue affected by it.

* Most of the calculations required to plot the curves here given have been made by Messrs. G. R. Giet and C. Mudge of our physical department.

The whole theory of the treatment of cancer by radium rays is based on the well-known fact that in general cancer tissue is more susceptible to the radiations than healthy tissue. By this is meant that, whatever the action of the radiation on the living cell may be, the same effect is produced in the cancer cell more readily than in the healthy cell. The nature and the extent of this difference in susceptibility depend chiefly on the nature of the cancer cell as well as on the intensity of radiation and the time of exposure. If the radiation is sufficiently intense it will have an unfavorable effect on the cells and the tumor cells will be destroyed more rapidly than the healthy ones. It should be noted, however, that the radiation intensity, the quality of the rays and the time of exposure for which this result is obtained, are not necessarily the same for all tumors and all patients, so that their experimental determination is very difficult.

So far we have tacitly assumed that both the cancer cells and the healthy cells are exposed to the radiation under the same conditions. But in actual cases the relative position of the diseased tissue and the healthy tissue usually is such that one receives a stronger radiation than the other. If the diseased tissue is near the source of radiation then obviously no serious mechanical difficulties will be encountered in the treatment. But for deep-seated tumors special precautions must be taken. In this case it is of great importance to consider the quality of the γ-rays to be used and the distance at which the source must be placed.

We know that if the intensity of radiation and the time of exposure are properly chosen, certain types of cancer cell will be affected from four to seven times more readily than healthy cells. Our problem, therefore, is to expose the tumor to a strong enough radiation for a sufficient length of time to cause its disintegration while the healthy tissue receives somewhat less than four times the dose which the tumor gets and hence is not affected harmfully. In order to show how this result can be obtained we shall consider a simple case. Suppose the patient under consideration has a nearly spherical tumor 2 cm. in diameter situated 1.5 cm. below the surface of the skin. Assume that we have diagnosed the case properly and we have decided that to affect the tumor a dose of m milliradions for

h hours of penetrating γ-rays is necessary. From this we know immediately that the intensity of radiation at the surface of the skin should not be greater than 4 m (assuming the power of resistance of the skin to be four times greater than that of the tumor).

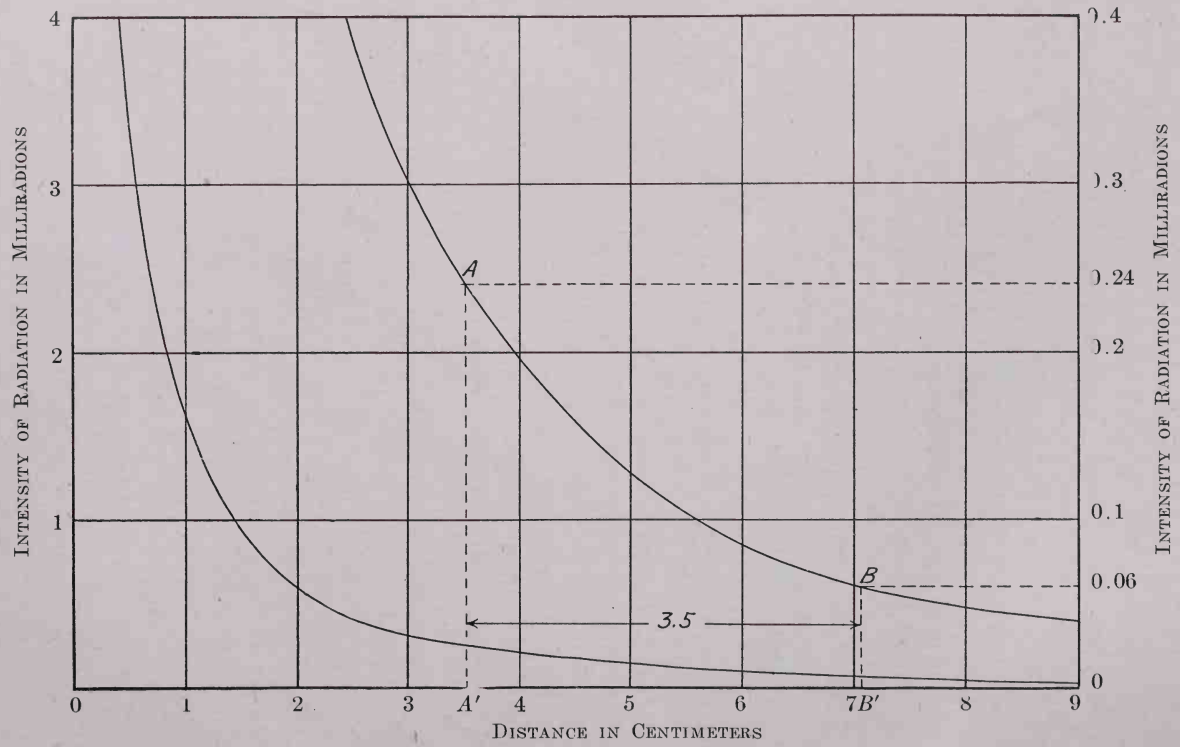
Let us say that we shall use a lead flat applicator which has an intensity-distance curve like the dotted curve in Fig. 3 which is shown to a larger scale in Fig. 4. In order to determine the distance at which the applicator must be placed we proceed as follows: The distance between the farthest point of the tumor and the surface of the skin is 3.5 cm. By trial we determine the position of A and B such that the distance AA′ ($= 0.24$) is four times the distance BB′ ($= 0.06$), while the distance AB is 3.5 cm. Then OA′ ($=$ 3.55 cm.) is the distance at which the center of the applicator must be placed in order that the skin shall receive four times the radiation which the farthest point of the tumor gets, assuming *no absorption* in the tissue.

The effect of absorption is to lower the curve slightly from point A on. Consequently in order that the skin shall receive per square centimeter no more than four times the radiation which falls upon one square centimeter at the back of the tumor we must place the applicator a little farther from the skin. If we plot the curve of absorption in the tissue of the particular quality of γ-rays used, we can determine accurately the proper distance at which to place the applicator and the intensity at different points of the tumor. But this is unnecessary because, in order to be on the safe side, in any actual case we should always take the distance considerably larger than the theoretical value. In this case if we put the applicator 4.5 cm. from the skin the necessary conditions will be satisfied.

It remains to determine the amount of emanation which the applicator should contain to give an intensity of m milliradions at the farthest point of the tumor. From the curve we see that using 100 millicuries in a flat applicator as described, at a distance of 4.5 cm. from the skin, we get 0.047 milliradions at the back of the tumor neglecting absorption, therefore, to obtain the proper intensity, we must use somewhat more than

$$100 \times \frac{m}{0.047} \text{ millicuries of emanation.}$$

FIG. 4.—DIAGRAM SHOWING THE METHOD OF DETERMINING THE PROPER DISTANCE OF APPLICATOR FROM SURFACE OF SKIN



The method of treatment just described is very inefficient from the energy standpoint. The energy of the α and β rays, which is nearly all the energy radiated by the emanation, is absorbed by the applicator. Of the small amount of energy which is radiated in all directions in the form of γ-rays only a small fraction falls upon the tumor and only a small part of this is absorbed by the tumor. The ideal way of treating a tumor would be to distribute the source of radiation throughout the diseased region. Then the α-, β- and γ-rays would all be effective, but the first two to a much greater extent. The reaction would, therefore, be more localized and a small amount of radio-active material would be sufficient to accomplish the desired results. This might be done by injecting an insoluble powder which has been previously exposed to the emanation so that the particles are coated with active deposit; or by injecting powdered carbon saturated with the emanation itself. The great difficulty is to keep the radio-active substance within the region that we desire to treat. It is hoped that eventually some such method of treatment will be devised.

We sometimes read in the literature that "distance is the best filter." To say the least this is a misleading statement. If by filtering is meant removing the soft rays then distance *per se* can never accomplish this. The *quality* of the radiations in a vacuum is the same near the source or a mile from it. But the intensity is different and, what is more important, the variation of intensity between two points, the difference of whose distances from the source is the same, is smaller the farther from the source they are. This is clearly seen in Table II. It is this fact which gives to "distance" its *apparent* filtering property. The farther from the skin the applicator is, the smaller the excess of radiation which the skin gets over the radiation falling upon the distant tumor per unit cross-section. Hence the smaller will be the effect on the skin while the tumor is affected to the same extent. Of course, if the source of radiation gives off α-rays the intervening air space will absorb them to some extent, but this case rarely occurs in practice because the α particles are usually absorbed by the material of the applicator. (Even in a varnish applicator, the varnish is sufficient to cut off most of the α-rays.)

To recapitulate, then, we may say that the important factors

in the specification of a dose are: (1) The intensity of radiation at different points of the tumor and at the surface of the skin. (2) The time of exposure. (3) The filter. Note that (1) includes implicitly the amount of emanation used, the distribution of the source, the distances from the skin and the tumor and also the filter. The latter, however, must be stated explicitly to give an idea of the quality of the rays employed.

In practice the exact specification of (1) is very difficult. Not only must we have the intensity-distance curves for the particular applicator used but also the dimensions of the tumor, its distance from the skin and the absorption of the rays by the flesh. As the dimensions of the tumor and its depth can only be determined approximately, it follows that (1) cannot be given accurately. This, however, is no serious drawback to this method of "dosage" because when we are dealing with living organisms there are many other factors which are more uncertain than this. It seems to me that the method of dosage here outlined is the best we can have at the present stage of the art. But any method which involves implicitly the factors stated above is equivalent to it. For instance, if we state the amount of emanation used, the distribution of the source and its distance, the filter, the time of exposure, and the dimensions of the tumor, we can calculate, if we wish, the intensity of radiation at different points of the tumor or neighboring flesh.

The method of dosage outlined in the preceding paragraphs has not yet been used at the Memorial Hospital. The preliminary work of determining the proper curves for each applicator, the absorption curves for different substances, etc., has just been started. It is hoped, however, that in the near future we shall be able to tell more accurately from experimental data just what filters should be used to obtain the best results and the maximum efficiency. Then we can design the applicators properly and determine the quality and distribution of the radiation from each applicator. The amount of absorption in different kinds of tissue for the quality of radiation coming out of each applicator should also be determined experimentally. When these researches have been completed we shall be able to specify the doses with much greater precision than is possible at present. A method of dosage similar to the one given here will then be adopted.

II

RADIUM THERAPY IN CANCER

HENRY H. JANEWAY

PRINCIPLES AND METHODS OF APPLICATION OF RADIUM TO CANCER

During the past two years 424 cases of malignant tumors have been treated with radium at the Memorial Hospital. It is the object of the present report to place this experience on record. It is an experience which has taught us much regarding the methods of application of radium to cancer, the field in which it performs its best service, and the dangers arising from a neglect of the therapeutic limitations of radium.

The acquisition of this experience has necessarily been slow, partly because of the length of time, often months, which it takes to estimate the effects of a single treatment. Further than this, although the Memorial Hospital now has a large quantity of radium at its disposal, it did not receive this quantity at one time.

The following schedule gives the dates and quantities received at various times by the hospital:

The Dates of Acquisition of New Quantities of Radium	Amount Received on These Dates	The Total Quantity to Which the Supply Was Increased
May 1, 1914	36.3	36.3
Feb. 15, 1915	89.9	126.2
April 15, 1915	139.0	265.2
May 7, 1915	130.0	395.2
July 18, 1915	114.6	509.8
Sept. 21, 1915	221.9	731.7
Jan. 28, 1916	376.6	1108.3
Jan. 29, 1916	297.1	1402.4
March 25, 1916	502.9	1905.3
Oct. 5, 1916	449.4	2354.7

A glance at the table shows that the Hospital has had in its possession large quantities of radium for only a relatively short time. Familiarity, therefore, with the effects of large quantities, especially of large quantities heavily filtered, at varying distances from the surface of the skin, has been only recently acquired.

The whole conception of radio-active therapy is based upon the belief that the tissues of malignant tumors are more susceptible to the influence of the radiations of radium than the normal tissues, and the aim of treatment is to take the greatest advantage of this difference by such a distribution of the source of radiation and by such a dosage that a complete destruction of the malignant tissue is accomplished with a negligible damage to the normal tissues.

This conception is so fundamental to a discussion of the methods of application of radium, that it is desirable not only to refer to those facts upon which it is based, but also to attempt to estimate how great is the difference between the susceptibility of malignant and normal tissues, though this can be done in only a very rough manner.

The mere fact that superficial epitheliomas of the skin can be made to disappear by appropriate exposures to radium without more than the slightest degree of erythema of the surrounding skin must form a convincing illustration that the cells of the epithelioma are destroyed with a dose which has a negligible action upon the normal epithelium. It matters not how much of this selective destruction is due to a direct action on the cancer cells or to the stimulation of an anticancerous activity in the neighboring normal cells.

The great susceptibility of rapidly dividing tumor cells to the radiations indicates that the destructive effect of radium upon tumor tissue depends in part upon its direct action upon the nucleus of the cell.

Though it is a mistaken idea that these comparatively benign cancers, the basal cell epitheliomas of the skin, are especially vulnerable to radium, it is not necessary to depend upon their response to radium in order to illustrate the special susceptibility of tumor tissue to it. The clearest examples of the selective action of radium on tumor tissue are furnished by the cellular teratomas and lymphosarcomas.

These tumors seem to melt away with the greatest rapidity whenever, one might almost say, radium is anywhere in their vicinity. They illustrate great differences in the reaction of tumor tissue to radium in comparison with the normal tissues; but the response of what is probably the most rebellious of all malignant tumors to any form of treatment, namely, epidermoid carcinoma, is marked by a contrast quite as decisive when its response is compared with the effects produced on the normal tissues by the same dose.

When, however, the attempt is made to measure more accurately the greater susceptibility of tumor tissue, considerable difficulty is encountered. Comparisons of the effects produced upon the normal tissues and cancer tissues are difficult to make because the normal tissues always show some effect from successful therapeutic doses applied to cancer. It is nevertheless worth while to attempt to form some conception of the quantitative differences which exist, even though this can be done only very roughly. Practically the only method available is to compare the dosage required to produce successful retrogression of tumor tissue without producing much effect on the skin or mucosa surrounding the tumor. Another method is to compare the dosage required to destroy the normal skin or mucosa and equal thicknesses of tumor tissue.

We have, for instance, repeatedly observed the definite retrogression of superficial epidermoid carcinomata by the application of 50 m.c. to the square centimeter of surface, when filtered through 2 mm. of lead and removed 4 mm. from the surface, and applied for 4 hours' time. The same dosage will produce a congestion and perhaps even an exfoliation of the most superficial layer of the cuticle. It will not, however, produce a destruction of the entire thickness of the epithelial layer of the skin, nor will 8 hours do this; though 8 hours will produce a destruction of considerable thickness of tumor tissue. To make another comparison using a little different filtration, 50 m.c. to the square centimeter applied to a superficial epidermoid carcinoma for 2 hours, through 1 mm. of silver, and removed 3 mm. from the surface will cause a complete retrogression of a lesion of similar size. One hundred millicuries in the same sized applicator applied for 24 hours produced a destruction of all the layers of the skin, and an

ulcer which took eight months to heal. Applied for 12 hours in an applicator 2 cm. square it produced a destruction of all but the basal layers of the skin and an ulcer which healed in three months' time.

Similar comparisons may be made between applications made in platinum tubes. Four platinum tubes, 1½ mm. thick, covered with 1 mm. of rubber, and containing 100 m.c. each, were applied directly to a small epithelioma of the tongue ⅜ to ½ an inch in diameter, and the surrounding mucous membrane, over an area a little over one square inch for two hours. The tumor retrogressed completely from this single application, without destruction of more than the superficial layers of the normal portion of the mucous membrane of the tongue.

On the other hand, as nearly as we can estimate, 8 hours of 100 m.c. with the same filtration will surely destroy the whole thickness of the mucosa. A single application of 12 hours' duration, the number of millicuries and the filtration being the same, applied to the skin has produced a destruction of all the layers of the skin, and an ulcer which took eight months to heal. Two of these tubes, each containing 100 m.c., have been applied relatively close to each other upon an epithelioma of the tonsil for eight hours, with a total disappearance of the malignant tissue, and only a partial destruction of the normal mucosa, which, however, in this case was protected to a certain degree by the tumor tissue.

Thirty millicuries in each of several 1-mm. platinum tubes placed near together has repeatedly caused the disappearance of considerable thickness, 5 mm., of epidermoid carcinoma of the mucous membranes in 2 hours' time, with but a negligible action on the mucous membrane. In one hour's time it will produce a disappearance of thinner layers of tumor tissue.

In another instance eight 1-mm. platinum tubes placed upon the surface of an epithelioma of the skin, 2 cm. thick, for 8 hours caused its complete disappearance with no effect upon the surrounding skin, which in this instance also was protected by the tumor tissue.

It seems, therefore, safe to draw the conclusion that in the use of these rubber covered platinum tubes the dosage required to destroy the normal squamous epithelial cells is probably two to four times that required to destroy epidermoid carcinoma.

In making this comparison between tumor tissue and the normal tissue we have attempted to compare epidermoid carcinoma with the mother tissue from which it arises. Such comparison is probably a very fair one, not only because they are similar tissues, but also because epidermoid carcinoma is a very malignant tumor, and one of the more difficult tumors to cure with radium or any other therapeutic agent.

With the exception of the still more malignant tumors, such as the teratomata and lymphosarcomata, the conclusion drawn in the case of the epidermoid carcinoma, that its cells are approximately four times as susceptible to the destructive action of the rays of radium as are the normal tissue, is roughly true for the majority of malignant growths, certainly including the tumors of the breast and rectum, and is at least a conservative conclusion, the actual difference being probably greater.

In any case, as a matter of practical experience, it has been found possible to produce clinically complete retrogressions in epidermoid carcinoma, even within lymphatic glands at some distance beneath the skin, without destroying the overlying skin. To obtain these results, however, even in the case of superficial tumors, it is necessary, because of the rapid decrease of the intensity of radiation with increasing distances from any applicator, to take advantage of every technical procedure which will favor the uniform distribution of the radiation throughout the affected tissue. By approaching as nearly as possible to such a uniform distribution there will be little difference between the dose received by the cancer tissue and the surrounding normal cells; and it will be possible to furnish the cancer cells with a maximum fatal dose without at the same time producing an injury to the normal tissue. This is a matter of the greatest importance because the injury to the normal tissues produced by radium is not one which heals readily. It is one which not only takes months to heal, but which is also accompanied by a proliferation of the connective tissue in the region exposed. This proliferation results in the production of a peculiarly dense fibrosis throughout the whole region.

Changes of these characters not only cause the patient severe pain, but also frequently a serious impairment of the function of the part. When they occur in the tongue its normal mobility is greatly impaired; when they occur in the esophagus, larynx or

rectum a stricture of these organs is sure to develop, which can in itself either terminate life, or produce a condition as uncomfortable as the original disease. In the earlier period of our work our technic did not permit of the same uniform distribution of the radiation as we now use. An attempt was then made to furnish from relatively few and rather cumbersome applicators the necessary dose for the more distant portions of the tumor by increasing the period of exposure. This method resulted in all the evils of overexposure to the tissues for some distance around the tube. It did not, moreover, in many cases, accomplish the total destruction of the carcinoma.

It has seemed to us that the degree of radium inflammation excited by the exposure has something to do with the success or failure to cure carcinoma. Certainly a radium inflammation of a very severe grade in no way diminishes the spread of the cancer, and at times it almost seems as though it actually favored the growth of the outlying incompletely treated cancer cells.

It may not be impossible that too severe radium inflammations so disturb the relations between the carcinoma cells and the stroma of normal tissue that certain growth controlling functions of the body's cells upon the cancer cells, and upon which recovery depends, are destroyed. Such functions have been described by Tyzzer * in connection with the mild inflammatory processes associated with the recovery of immune Japanese waltzing mice to inoculated tumors.

In any case it remains a fact that the severe radium inflammations are objectionable, not merely because of their chronicity and the suffering which they cause, but also because they materially diminish the probability of a cure.

In attempting to cure cancer by radium it must be recognized that not only is there an optimal dose of radiations for the cancer, but also that only small deviations from this optimal dose, particularly at the first treatment, will make all the difference between success and failure. In order to furnish this optimal dose to all portions of the cancer the radio-active source must be so placed in relation to all parts of the cancer that the safe limits for the healthy tissues in any part of the field of treatment are not exceeded.

* *Journal Medical Research*, 1915, XXXII, 201.

The variation of the intensity of radiation with distance from a bare emanation tube is shown graphically in Fig. 2, p. 42. It will be readily seen that the radiation decreases very rapidly as the distance from the tube increases. Thus if we place a bare emanation tube, containing the proper amount of emanation, upon a new growth, neglecting for a moment the absorption due to the tissue, and so adjust the duration of exposure that a cell 0.5 cm. from the center of the tube will receive a proper dose, a cell at a distance of 1 cm. (that is, twice as far away) will receive approximately only one-fourth as much, and a cell 2 cm. away roughly only one-sixteenth as much. All cells nearer than 0.5 cm. of the tube will receive more than the proper dose, the excess being greater the nearer they are to the tube.

If we take account of the absorption due to the tissue we find that the drop of intensity is much more rapid, because the β-rays and soft γ-rays are absorbed to a considerable extent.

Obviously the most natural method of securing uniform distribution of the radiation throughout a tumor mass is to use a large number of centers of radio-activity within the invaded tissue. Practical considerations, however, limit the possibility of indefinitely multiplying the centers of radiation throughout tumor tissue, that is, when radium emanation enclosed within tubes is used. Theoretically the insertion of many small glass tubes within a tumor in a manner to actually make the whole tumor bristle with many tubes or with emanation-containing needles, after the manner suggested by Duane, will accomplish this result. Unless we are dealing with a very superficial epithelioma of the skin the little tubes or needles must be inserted within the tissue in order to retain them in place.

In the case of a superficial epithelioma of the skin almost any number of these small emanation tubes, each containing a very small amount of emanation, may be laid upon the surface of the ulcer, and easily retained in place by merely covering the whole lesion and the tubes with a little cotton, which in turn can be held down upon them with adhesive plaster. In case the ulcer is superficial, involving only the skin, which is freely movable upon the deeper parts, the radiation from the combined tubes will penetrate efficiently throughout the whole thickness of the lesion without exposing the tissue in the immediate prox-

imity of each tube to a dosage unnecessarily destructive to the normal tissue. Such a method of treatment finds a useful field in certain superficial growths in the neighborhood of the eye or near some delicate tissue, overexposure of which is more serious than overexposure of less important and less sensitive tissue. The retina of the eye is very sensitive to radium, and must be protected whenever possible from strong radiation. Moreover, many epitheliomata near the eye, particularly those near the inner canthus, are situated in such corners and recesses that they can be accurately covered by radium only by using many minute tubes. The larger, more highly filtered containers in a few instances cannot be satisfactorily applied to these ulcers.

Whenever, on the other hand, we are dealing with ulcerated growths which have penetrated more deeply the underlying tissue, or even relatively superficial growths upon mucous membranes, it is undesirable to make use of these tubes. They can, of course, be fastened to the surface of a gauze pad in a form corresponding to the shape of the ulcer, and laid upon the ulcer by inverting the pad upon it. Even, however, with the greatest precaution to avoid misplacement, there is some danger within such a cavity as the mouth, with the impossibility of restraining all movement of the tongue, that the gauze pad will not stay where it is put, even if attempts are made to sew the pad in place. Both sewing the pad in place and inserting in the tissue the glass emanation tubes or needles containing them are objectionable. The trauma to the tumor is harmful and the discomfort is undesirable. Moreover, within the cavity of the mouth there is a very real danger that some of the tubes or needles may slip loose and actually be inhaled or swallowed. A further objection to the use of these small tubes is the fact that in the case of the deeper growths we cannot count upon a regularly circumscribed lesion. In the majority of the lesions of the tongue there will be at the time the case presents itself for treatment irregular extensions through the lymphatics, passing to the regional glands. Case C. N. No. 23153 (page 141) furnishes an illustration of this fact. In this man we had to deal with a relatively superficial early lesion of the tongue upon the left side. His lesion completely retrogressed under treatment, but nine months later a recurrence took place upon the

opposite side of the tongue. Evidently there had been a relatively long extension in the direction of this recurrence at the time of the initial treatment. The tendency for these early lesions to invade the regional lymphatics in linear extensions is only another illustration that these tumors cannot be considered to be limited to the region most obviously involved. The same may be said of the relatively more benign metastases of cutaneous epithelioma which have invaded the subepithelial tissue, or especially of those growths which have been treated by the *x*-rays or previous excision or caustics, and have recurred. They then become the most difficult of growths to cure. After they have apparently been healed a fresh outbreak of the disease will occur at some place where it is least expected, demonstrating that at the time of treatment a long linear extension in the direction of the recurrence existed. It is impossible to attempt to reach these linear extensions by the insertion of needles deeply into the substance of the tumor, even if care is exercised to place them in the direction of the lymphatics which pass to the regional glands. Though extension in the direction of the regional glands in the case of epidermoid carcinoma is most probable, extension in other directions cannot be excluded, so that any attempt to head off the growth in the direction of its extensions is impossible without bringing a sphere of surrounding tissue under radiation.

Any method which aims to do this by penetrating the tumor and a zone of the surrounding tissue by needles or small tubes, each possessing a relatively small sphere of effective influence around it, is uncertain and cumbersome; to the tumors of the mucous membranes it is damaging; and, from the standpoint of tumor growth, it is dangerous.

It is far better in the more deeply seated lesions to make use of relatively fewer applicators, but of applicators so filtered that the radius of effective influence around each is much greater.

In order to understand the principles concerned in the increased depth of the action of radium by filtration, a familiarity with the curve of absorption is necessary. Fig. 1, p. 40, illustrates the decrease in the intensity of radiation produced by filtration through various thicknesses of lead. It will be seen that the first millimeter of lead decreases the radiation enor-

mously. An additional millimeter of lead also produces a considerable drop in the intensity, but not so great as the first. This shows that most of the radiation is easily absorbed, and therefore, when the emanation is used without filter, most of the radiation is absorbed by a small thickness of tissue, and the deeper tissue does not get a proper dose, while the superficial tissue gets an excessive dose.

But when the emanation is properly screened, by two or three millimeters of lead, for instance, the soft rays are absorbed by the filter, and the penetrating rays which emerge are not rapidly absorbed by the first layers of tissue traversed. The decrease of intensity due to this absorption, therefore, is small, and the tumor as a whole receives a more uniform radiation.

Of course the lead diminishes very much the amount of radiation coming off from the radium, but this loss is easily made up from the patient's standpoint by lengthening the time of the exposure, and increasing the amount of emanation in the applicator.

The increased size of the sphere of effective radiation surrounding an emanation tube strongly screened as compared to an unscreened emanation tube, and therefore the greater effectiveness of covering a malignant ulcer with emanation tubes enclosed in platinum, can be more accurately estimated by figures showing the actual relative decrease of radiation at successive millimeters from unfiltered and filtered emanation tubes.

On page 42 is shown the intensity curve for a bare emanation tube, and on page 40 that for the same tube enclosed in a lead tube 2 mm. thick. It will be seen that the radiation intensity is 470 units at a distance of 3 mm., and 60 units at a distance of 12 mm. from the bare tube containing 100 m.c. The corresponding values for the intensities at distances of 3 mm. and 12 mm. from the center of the lead tube are 11.4 and 1.63 units respectively. Therefore, the intensity of radiation at a distance of 3 mm. is nearly eight times greater than at a distance of 12 mm. in the case of the bare tube, and seven times greater in the case of the lead-covered tube.

At first sight, therefore, it would seem as if there is not much difference between the two. But the quality of the rays coming out of the tubes in the two cases is very different. Most of the radiation from the bare tube consists of beta rays, and they,

as well as the soft gamma rays, are absorbed by small thicknesses of tissue, so that the intensity at 12 mm. from the bare tube applied on the skin is very much less than 60 units, perhaps only 15 or 20 units. But the radiation from the lead tube is only slightly absorbed by the tissue and it is evident then that the actual difference between the two cases is very great.

The difference is even greater if we measure the distances from the surface of the lead tube and from the surface of the bare tube. The intensity 3 mm. from the surface of the lead tube is 5 units, 13 mm. away it is 1.4, or 3.6 times less. The corresponding ratio for the bare tube is nearly eight as we have seen. (The emanation tubes are so small that we can neglect the distance from the center to the surface in this case.) So even without considering the absorption of the soft rays by the tissue in this case there is a considerable difference in favor of the filtered source of radiation.

We have compared the bare emanation tube with a tube filtered by two millimeters of lead, but the same conclusions can be drawn for platinum tubes having the same filtering capacity. The main advantage of the platinum tubes lies in their lightness.

If, therefore, we regard it as undesirable to supply the surface of a cancer with more than four times the dosage desirable at the assumed position of the deepest cancer cell, only the superficial layer of cells will receive a sufficient dose from an unfiltered emanation tube; whereas if the tube is enclosed in 1 mm. of platinum all cancer cells to a much greater depth will receive an effective dose. If, on the other hand, we regard it permissible to overtreat the first millimeter of tissue, we will increase the depth of efficient penetration of the heavily filtered radiations to a very much greater degree, with far less overtreatment of the superficial layer of cells, than when relatively unfiltered radiations are applied.

In the case which we have been considering the source of the radio-activity is a line, but if the whole surface of the tumor is covered by a good many such lines, a condition is approximated in which the source of radiation is a plane surface, corresponding in size to the surface of tumor. Such a condition is approached when a tumor is covered with several emanation-containing platinum tubes held in pleats sewed in muslin, or

when the lead plaques which we have described are filled with emanation tubes. In making use of such applicators we are, practically speaking, covering a tumor with a plane radiating surface.

From such a plane surface the radiation diminishes with the distance at a far lesser rate than it does from a single tube or line. Consequently in attempting to pervade a tumor uniformly with radiation a second method of insuring this result will be the spreading of the radium or emanation out over the surface of the tumor.

Excited, however, in the lead are secondary rays of a character resembling both the gamma rays of different degrees of hardness and beta rays. These secondary rays probably do not seriously alter the surface effect. We believe, however, that they are present in sufficient numbers to make it desirable to filter them out by a thin layer of aluminum or rubber or gauze.

The theoretical advantages of the strong degree of filtration in deep lesions and the use of plane surfaces of radiation have been fully confirmed by the results of their use. For external application we have adopted 2 mm. of lead. For application to the mucous membranes we use 1 mm. of platinum iridium. One mm. of platinum iridium corresponds in its filtering power to 2 mm. of lead. Tubes made of platinum iridium are very small and light. For the more superficial lesions and the superficial portions of the deeper growths we use tubes of $\frac{1}{10}$-$\frac{1}{2}$ mm. of German silver. No special device is needed for retaining these tubes upon the surface of superficial lesions within the anterior portion of the mouth. They may be sutured or tied to a gauze pad, and this inverted over the lesion or best embedded in molds of dental composition. The gauze packed over these serves a double purpose: it holds the radium tubes in place, and at the same time separates the normal mucosa opposite the lesion from the applicators. This method of protecting the normal tissues by distance is best.

The rapid decrease of radiation from small sources, approximately proportional to the square of the distance, makes the method of separating the opposite mucous surfaces by gauze packing safer and more serviceable than by interposing a piece of thick metal. Such a piece of metal must be equivalent in its filtering power to at least 1 mm. of lead, and a piece of lead

of this weight and thickness cannot be introduced within the mouth or vagina. If it is introduced as a filter over the applicators it will not only displace the applicators and render the whole application so uncomfortable, that the difficulty of maintaining the accuracy of the application becomes insurmountable. Further than this, secondary rays are given off from the surface of an interposed piece of lead, which, in two cases we have attempted to protect in this manner, have caused a mild burn on the very surface, which it was intended to protect.

Gauze packing is not sufficient in many cases to maintain the applicators in good position. In many locations within the mouth, particularly on the tonsil, back of the tongue and in the pharynx, some special retentive means must be adopted to assist in holding the applicators in place. This means will be described with the detailed description of the applicators themselves.

While the combinations of the thin German silver tubes and the 1 mm. platinum and 2 mm. lead tubes have greatly increased the efficiency of surface applications upon the skin and mucous membranes, and have made the treatment of the majority of these lesions entirely successful and much simpler than by the burial of emanation-filled needles beneath the surface, yet they have not altogether done away with the use of needles or centrally placed relatively unfiltered applicators. The anatomical structure of certain organs of the body is such that the relation of cancer starting within them to the normal boundary of the organ confines the growth in many instances to within easy reach of a centrally placed application. Moreover, the nature of the tissue is such that an excited radium inflammation confined within the capsule of the organ is neither painful nor, it appears, harmful.

In the case of the prostate it has been found possible to insert an emanation needle through the perineum within the center of the organ, and treat the whole organ with one or two such needles, or one needle in two positions, with a strong exposure. In this instance, although a relatively unfiltered emanation needle is used and placed in intimate contact with the tumor tissue, yet the method owes its success to the fact that it is really a prolonged, distant application from the center of an organ so adapted by the peculiar relation between its cancer tissue and the capsular covering of the organ that the cancer

tissue itself forms the filter to the radiations. This tissue is so confined in the favorable cases by the capsule of the organ that in acting as a filter it is totally destroyed and disappears to the internal surface of the capsule, which itself is of such a thick, dense structure that it will bear very strong exposures without harmful consequences.

In such locations as the prostate and cervix uteri it is possible to make use of relatively unfiltered rays and prolonged exposures, but whenever doing so the real principle made use of must not be confused with another, which it only resembles. It is essentially a distant form of treatment, from a centrally placed, single applicator, filtered by the surrounding tumor tissue. The method is followed by the most disastrous consequences when used upon lesions or organs not especially adapted for it, as the tongue. Within, however, such an organ as the uterus or cervix, and in the case of selected cancers of the esophagus and rectum, it is equally successful. In a somewhat modified form it has been successfully used in some superficial cancers.

In the case of Bryson we had to deal with a primary, new growth of the skin of the chin. The tumor formed a rather elevated, ulcerated, but well circumscribed mass. It was treated with 100 m.c. of emanation, contained in two applicators of only 1 mm. of silver, for 24 hours. The applicators did not overlap the edge of the ulcer. Inasmuch as the tumor tissue was fairly thick, it formed an efficient filter. The single application cured the lesion, without the slightest damage to the surrounding normal tissues, although a similar application to the normal skin would have produced a burn which would have taken months to heal and would have caused much suffering.

The degree of filtration is not the only means of diminishing the difference between the amount of radiation which the surface of a lesion and the deeper portions receive. Two other means may be used to insure a still greater uniformity of radiation. One of these is to cover not only the whole surface of the tumor, but a zone of healthy tissue around it, with the applicators. Such a flat distribution of the radium, as it were one-half way around the tumor, subjects it to a cross fire, though only a cross fire directed from one side, which approximates to a degree that ideal condition which would obtain if we could

completely surround the tumor with radium. If, for instance, we could radiate a tumor by completely surrounding it with a sphere or cylinder of properly filtered radium emanation, every portion of the tumor within the sphere or cylinder would receive an equal amount of radio-active energy, minus, of course, the small quantity accounted for by absorption. This condition is nearly approximated by surrounding a malignant tumor or

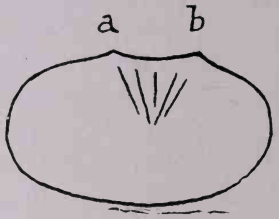


FIG. 5

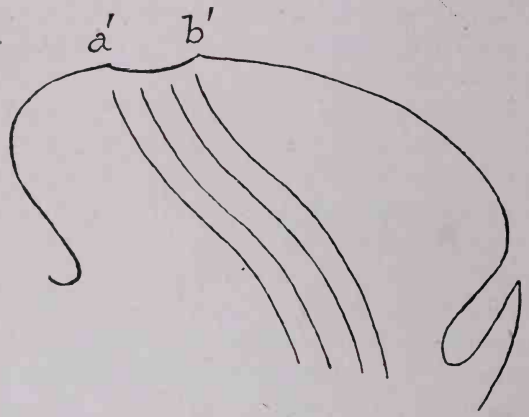


FIG. 6

sarcoma of an extremity by radium. Here the only failure of perfect uniformity of radiation is the small diminution of radio-active energy caused by absorption. The more completely, therefore, that a tumor can be surrounded by a surface of closely packed emanation tubes the more uniform will be the radiation of the enclosed area.

The tumors best adapted for this form of radiation are the sarcomata of the extremities and the lymphatic tumors of the neck. It is true that the latter can only be partially surrounded,

but the difference nevertheless which this treatment makes is very striking.

The necessity of including within the area to be covered a surrounding zone of apparently healthy tissue, provided this zone is not too wide, is of the greatest importance in the treatment of many epidermoid carcinomata of the mucous membranes, particularly those of the tongue. If, for instance, a tumor of the mucous membrane of the tongue is to be treated, which is represented on coronal section by the raised border and excavated surface *a b* (Fig. 5), and on sagittal section *a′ b′* (Fig. 6), it must be recognized that the borders at *a* and *b* and *a′* and *b′* contain the most actively growing cells, and should receive the full dose required. If now the application is only limited to the area inclosed within the raised margins of the ulcer, as illustrated by the circles 1, 2, 3, 4 (Fig. 7) represent-

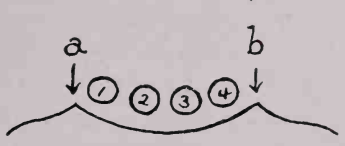


FIG. 7

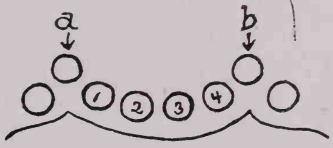


FIG. 8

ing the tubes on cross section, then any cancer cells to the outside of *a* or *b* will be receiving considerably less radiation than the cells in the center of the ulcer. If, however, the tubes are placed as represented in Fig. 8 the cells on the border of the ulcer will receive the full dose without the danger of overtreating the center of the ulcer.

Special care should be exercised to cover the ulcer well upon the side from which the lymphatic vessels pass to the regional lymphatic glands. From the tip of the tongue these pass backward, in the direction of the long axis of the tongue, and from ulcers on the borders of the tongue both in the longitudinal axis of the tongue and in a vertical direction toward the submaxillary gland as indicated in Fig. 6.

The second additional means of securing uniform distribution of radiation is of still greater importance. It consists in removing the emanation-holding surface at a distance from the tumor. If we are required, for instance, to treat a tumor (Fig. 9, [A]) beneath the surface of the skin, B B, by an applicator

represented by C C, the tumor (A) will receive from point C the rays included between the angle E C D, while the portion of the skin directly above the tumor will receive all the rays included between the angle D C F. The skin will, therefore, be receiving from the point C much more radiation than the tumor (A). What is true of C is also true of all other points in the

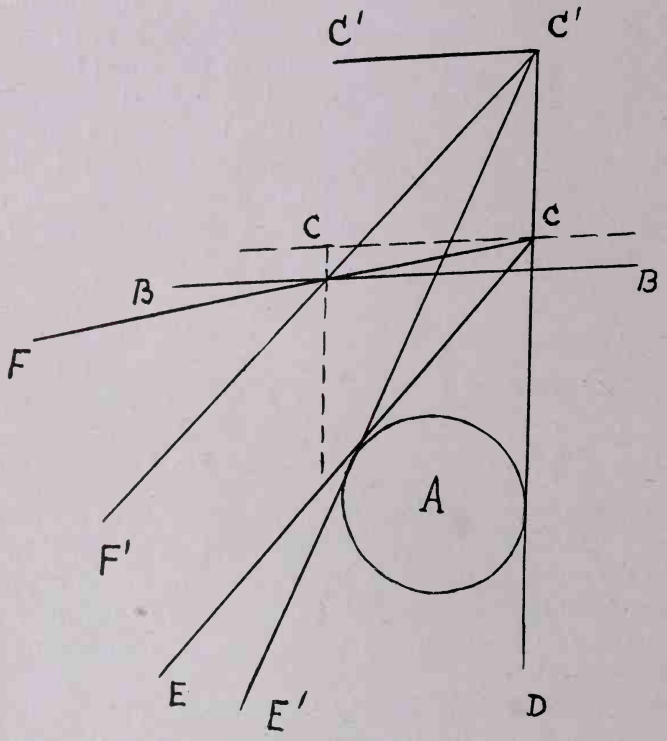


FIG. 9

surface, C C, so that from this surface the skin, B B, is receiving much more radiation than the tumor A. If now we remove the radium or emanation-holding surface to the position of C′ C′, the tumor (A) will receive from the point C′ radiation represented by the angle E′ C′ D, while the skin receives the radiation included within the angle D C′F′. To be sure the angle D C′ E′ is more acute than the angle D C′ F′, but the difference between the two is small in comparison to the difference be-

tween angle D C E and angle D C F. Hence the skin receives much less and the tumor only slightly less radiation when the applicator is placed in position C′C′ than when it is placed close to the skin.

To conclude, the methods of application may be enumerated as follows:

(1) By numerous minute, unfiltered or lightly filtered emanation tubes (0.1 to 0.5 mm. German silver or .25 mm. aluminium). Such tubes are best supported in molds made of dental composition, and their use is indicated on all superficial lesions or the superficial portions of more advanced growths.

(2) Central applications of one or few tubes, highly filtered, or relatively unfiltered, except by the tumor tissue, and depending upon the limited character of the growth and the structure of the organ for the completeness of the radiation.

(3) Deep radiation by the use of strongly filtered emanation tubes, arranged side by side, so as to form flat surfaces of emanation, placed in direct contact with the tumor.

(4) Distant, highly filtered emanation surfaces, placed either over the tumor so as to surround it from one side, or better still, whenever possible, in a manner to completely surround the part of the body bearing the growth. The method is highly efficient and provides fairly uniform radiation of all the deep tissues.

APPLICATORS

Corresponding with these different methods of application we have made use of five different types of applicators:

(1) The simple emanation-holding glass tubes. These are ⅜ to ½ in. long, and less than ½ mm. in diameter. They may be inserted into the tissue, or laid upon it, or may be sealed into long, aspirating needles (Fig. 10, A), which can then be inserted within cancer tissue.

(2) Tubes of .25 mm. aluminium or 0.1 to 0.5 mm. German silver for light filtration and protecting the bare emanation tubes.

(3) For central strong application heavier filtration is as a rule desirable, and for this purpose, as well as for surface application to mucous membranes, the platinum iridium tubes

(Fig. 10, B, C, D, E, F, G) have been constructed. The tubes are formed of a central portion, which is drilled for the reception of the emanation tubes. This is closed by two little caps, which screw over the ends (Fig. 10, F). Each cap contains a threaded socket upon its distal end, into which may be screwed the base of the hook, C. This hook is of small size, and con-

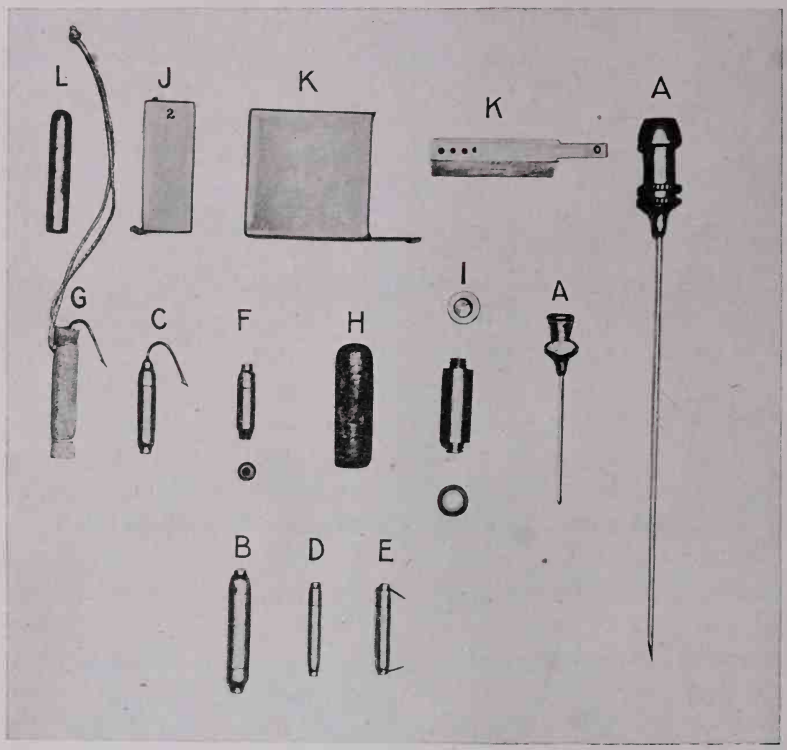


FIG. 10.—SHOWING VARIOUS FORMS OF TUBES AND SILVER PLAQUES (Described in Text)

tains a very fine barb. When the hook is screwed into the end of a tube the tube may be hooked upon almost any ulcer or mucous surface, and can be counted upon to retain its position. This method has given us successful results in the treatment of epithelioma of the tonsil and epiglottis and back of the tongue.

More recently we have made molds of intra-oral and even intravaginal and intrarectal tumors of dental modeling com-

pounds. Within the areas on these molds corresponding to the tumors properly filtered emanation tubes are embedded. We

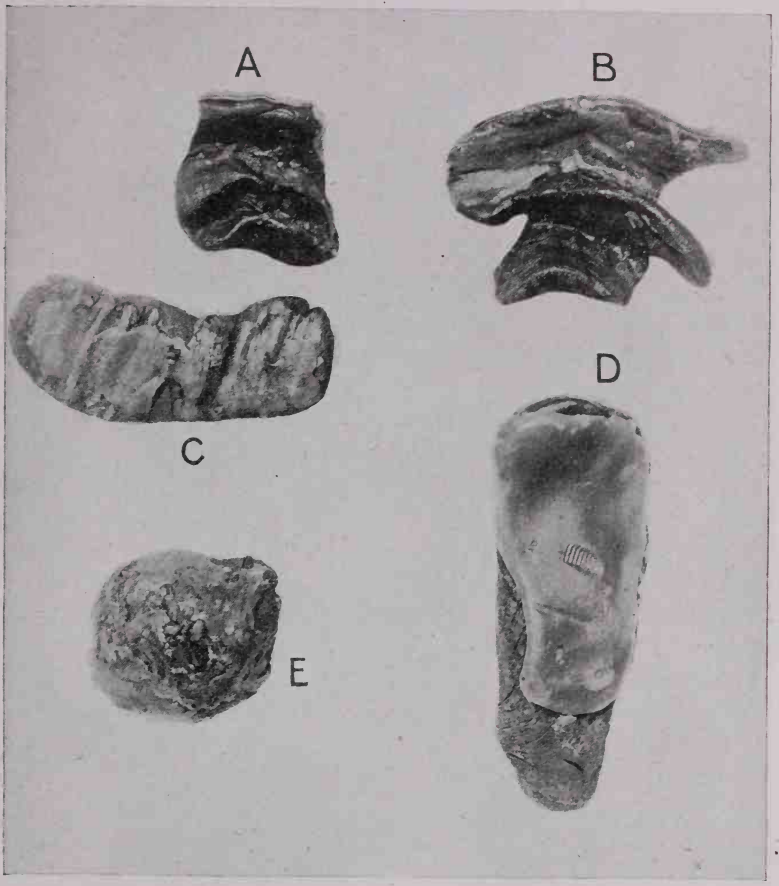


FIG. 11.—APPLICATORS MADE OF DENTAL COMPOUND

A, B and E, applicators made to fit over the lower lip, showing the indentations made in a portion of the applicator which fits over the teeth, thereby affording stability when in place. D, similar applicator made for fitting into the vagina. The facing surface shows the tubes covered with a layer of paraffin 1 mm. thick. C, similar applicator made for covering a superficial lesion of the skin.

have found these applicators most successful and capable of the widest application (Figs. 11 and 12).

The platinum tubes are made in three sizes:

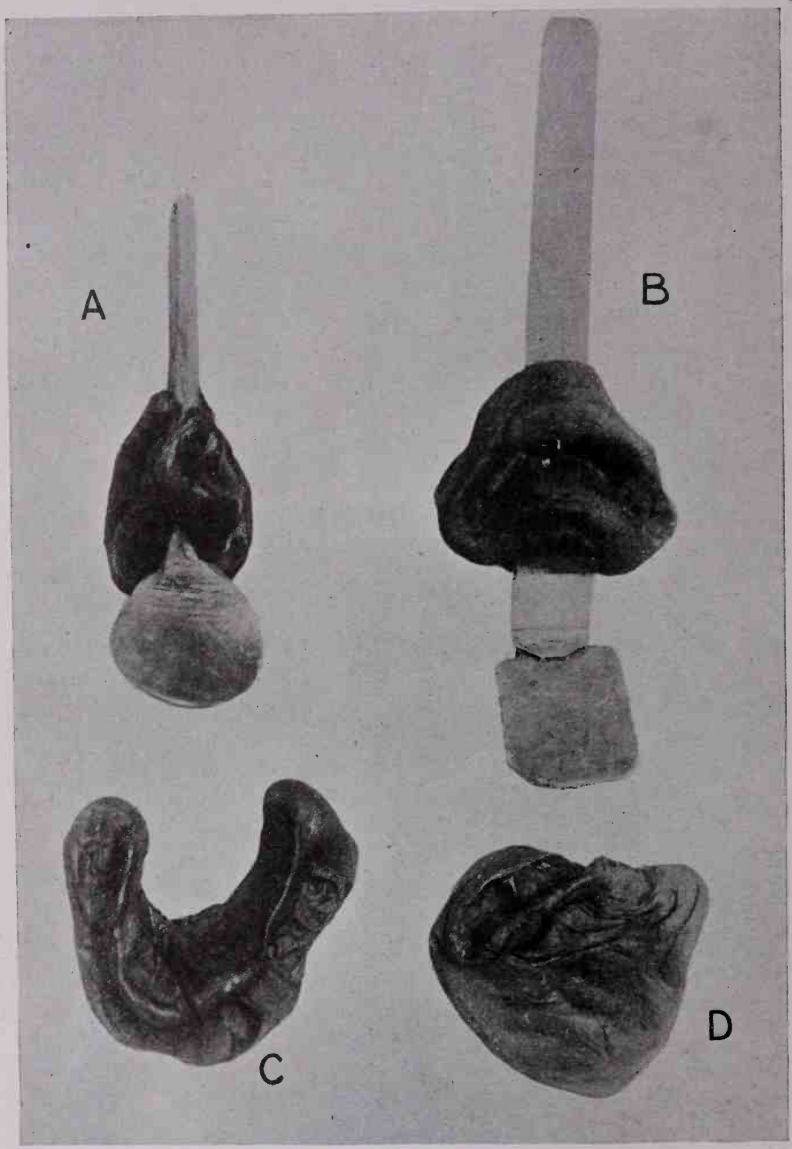


FIG. 12.—APPLICATORS OF DENTAL COMPOUND DESIGNED FOR TREATING LESIONS OF THE BACK OF THE TONGUE (B), SIDE OF THE TONGUE (C AND D), AND TONSIL (A).

I. With a bore of 2 mm. and wall 1½ mm. in diameter (Fig. 10, B), giving approximately the filtration of 3 mm. of lead. The drilled central portion is 2 cm. long. A good many weak emanation tubes may be inserted within tubes of this size. They are serviceable, therefore, for the administration of heavy

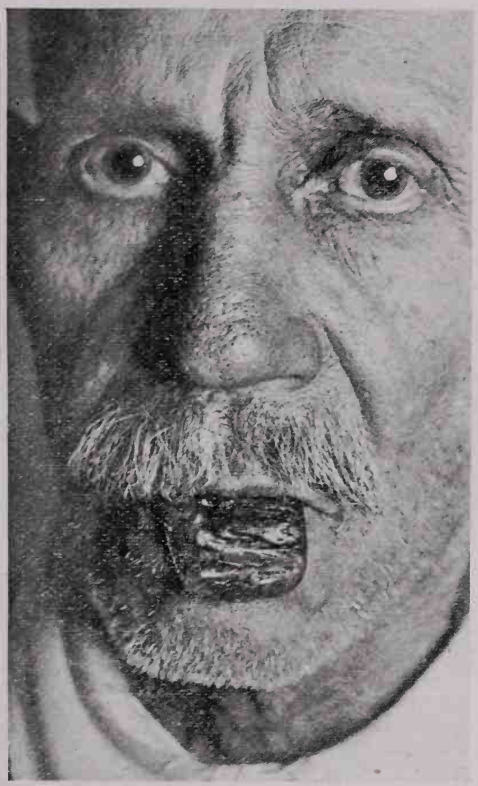


FIG. 13.—SHOWING AN APPLICATOR OF DENTAL COMPOUND IN PLACE UPON THE LIP

dosage, and permit the emergence of only very hard, practically homogeneous gamma rays.

II. A tube with a bore of 2 mm. and a wall of 1 mm. in thickness (Fig. 10, C and F). Its drilled central portion is 1¼ cm. This tube also can be filled with many emanation tubes, and, therefore, a relatively very strong dose. It gives a filtering power of 2 mm. of lead, and while the emerging rays are not

quite so homogeneous as those from the tubes with walls 1½ mm. thick, they are nevertheless very hard, and the greater lightness and smaller size of the tube adapt it for better use and a more exact application in the case of many of the lesions inside the mouth.

III. A tube, the bore of which is 1 mm. and the walls 1 mm.

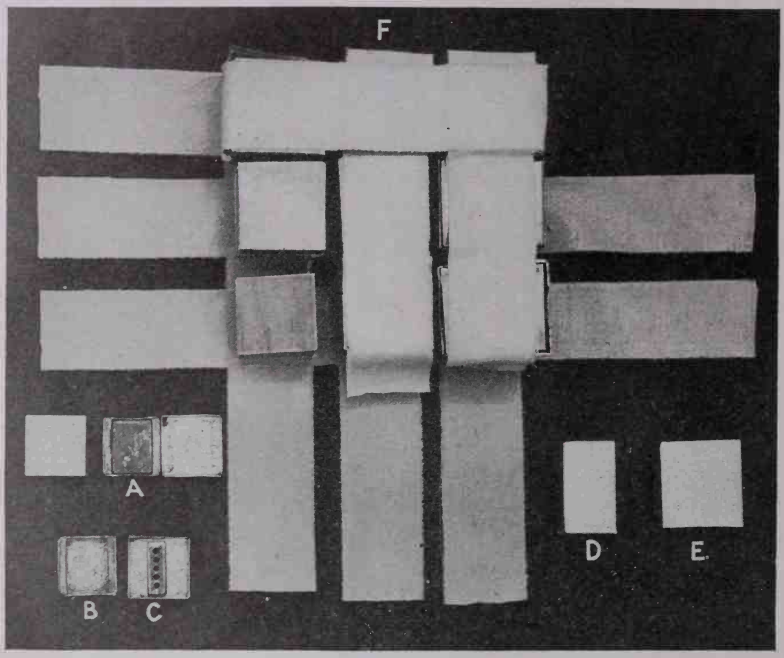


FIG. 14.—SHOWING THE CONSTRUCTION OF THE RADIUM PACK BY WHICH MANY EMANATION TUBES ARE SPREAD OUT OVER A SURFACE 9 x 12 CM.

Enclosed in separate plaques of lead 2 mm. in thickness around the centrally drilled holes containing the tubes.

in thickness (Fig. 10, D and E). Its drilled central portion is 1¼ cm. long. It possesses all the filtration advantages of tube Number 2, or of 2 mm. of lead, but it will contain only one emanation tube. If it is desired to fill this tube with a strong dose, a new emanation tube must be inserted. When only weak emanation tubes are available, these tubes cannot be filled with strong doses. The use, however, of weak doses within them is not an unqualified disadvantage, as the sufficient dosage can be made up by longer exposure, and as these tubes are smaller,

more of them can be inserted upon the surface of a growth, and, therefore, a more uniform distribution of the total dosage secured.

This third tube is the most useful one which we have. As has been explained, by placing these tubes side by side a sur-

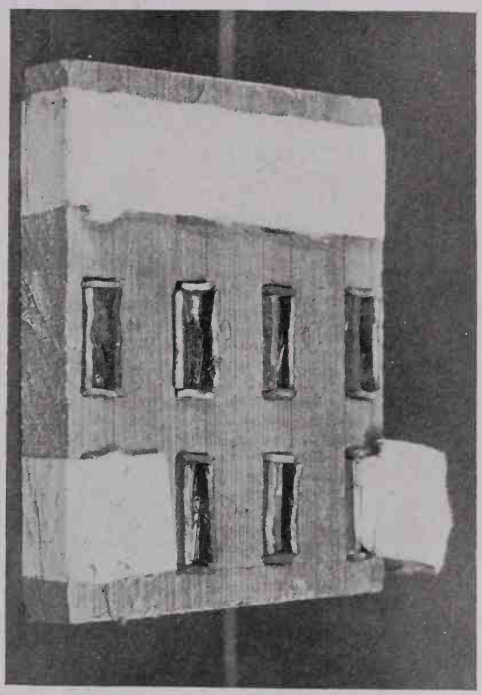


FIG. 15.—AN IMPROVED APPLICATOR FOR TREATING WITH HEAVILY FILTERED EMANATION AT A DISTANCE FROM THE SKIN SURFACE.

The applicator consists of a board in which are sunk little lead trays of 2 mm. lead. Into these trays large numbers of old emanation tubes may be placed. The applicator measures 12 x 10 cm. and is much lighter than that made of the lead plaques, though not so light as the pack made of platinum tubes. It makes a convenient method of utilizing weak emanation tubes for a long period and yet contains in toto a large number of millicuries.

face of emanation may be obtained. Used in this manner they form the most serviceable applicators for deep penetration on lesions of mucous membranes which we possess.

The small size of the third tube makes it possible to insert these tubes within all the crevices and irregularities of malignant ulcers, and far enough over their borders to construct from

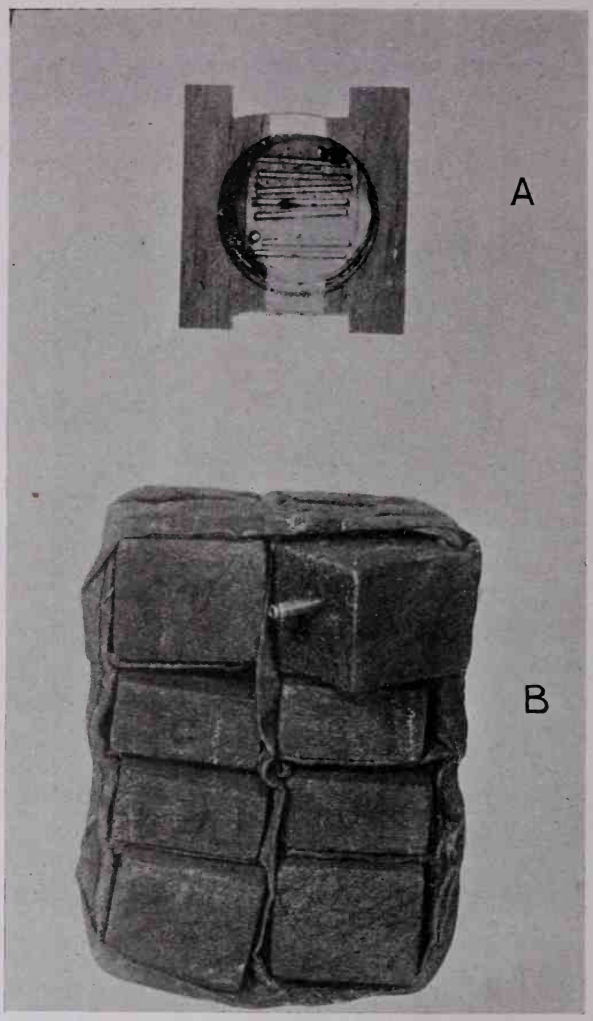


FIG. 16.—APPLICATORS FORMED WITH WOODEN BLOCKS

A, a form of applicator made of wood 2 cm. thick, through which a hole 1 inch in diameter is drilled. The emanation tubes are shown adherent to the adhesive plaster, covering one end of this hole. The open end of the applicator is applied to the surface of the lesions. In this form of applicator slightly filtered radium is used and it forms a method of treating superficial lesions at a distance from the lesion with soft *gamma* and *beta* rays.

B, a form of applicator constructed of several blocks of wood which are drilled to receive the 1 mm. platinum tubes. These tubes may be filled with strong emanation tubes and the applicator forms a method of treating lesions with evenly distributed radium emanation, strongly filtered, and yet contained in a very light applicator which may, therefore, be placed at considerable distance from the lesion without much discomfort or inconvenience to the patient.

the combined number a surface applicator very accurately adjusted to the requirements of any ulcer.

For centralized strong applications to many rectal or esophageal or cervical cancers, or even for centralized strong applications to many deeply excavated superficial carcinomatous ulcers, tubes of lead may be advantageously used. These tubes are similar in construction to the platinum tubes. The caps of these tubes do not possess the sockets for the attachments of the hooks. They are illustrated in Fig. 10, H and I.

(4) For external use upon flat surfaces square plaques of lead (Fig. 14, A, B, C, D, E) and silver (Fig. 10, J and K) are used. The plaques are 6 or 8 mm. in thickness, and drilled with parallel holes, 2 mm. in diameter (Fig. 14, C). A thickness of 2 mm. and 3 mm. of lead, therefore, exists between these holes and the surface of the lead. The ends of the holes are closed by end pieces of 2 or 3 mm. in thickness (Fig. 14, B), and the plaque and its ends held together by a little box made of ½ mm. of aluminum (Fig. 14, A, B, C). Tubes of emanation are placed within the parallel holes, and as many plaques as are needed arranged together to cover a large surface (Fig. 14, F). These plaques are 1 inch square, and ½ inch square, and ½ by 1 inch. By means of them the emanation may be spread out practically uniformly over a flat surface. The aluminum box not only serves to hold the applicator together, but it also filters out some of the secondary rays from the lead. These applicators are always separated from the surface by a few layers of gauze.

(5) The fifth form of applicator is made by either combining these lead plaques (Fig. 14, A) or filling little lead trays sunk into a small board 10 x 12 cm. (Fig. 14, B). The pack then forms a flat radium surface of some size, capable of being applied over a considerable area of skin, at a uniform distance from the surface. The advantage of such a pack over the direct application to the surface became at once apparent when it began to be used. The separation of 2 cm. from the surface practically eliminated a radium inflammation, and yet permitted the administration of doses sufficient to produce retrogression of deep-seated tumors, such, for instance, as, in some instances, metastatic epidermoid tumors of the lymphatic glands of the neck. More recently we have separated the block of wood from

the skin by an additional 2 to 3 cm. of gauze, and have found in this still greater separation of the radium from the skin a greater advantage (Fig. 16).

The failure to make use of any of these methods and applicators for obtaining uniform distribution of the radium to a number of the patients with cancer, who were treated when the work at the Memorial Hospital was first begun, and the progressive adoption of them in the later cases treated, have been responsible for a continuous improvement in the results as time went along.

Case D. O. No. 21593 (page 140) was treated with small quantities slightly filtered applied repeatedly. His disease was hardly checked, although some healing on the surface was accomplished. Eventually he developed a rapidly spreading, deep infiltration, with considerable surface irritation.

Cases F. S. No. 21869, C. N. Hosp. No. 23153 (page 141) and J. L. Hosp. No. 23060 (page 137) are other illustrations. They were treated with centrally placed strongly filtered emanations. None of these patients had a recurrence at the site of the original lesion. Unquestionably the ultimate result was due to a failure to cover a large enough area.

Dr. Ewing has called our attention, however, to the necessity of applying strongly filtered radium emanation with much caution when it is applied directly, and particularly is this true in the case of lesions of the mucous membranes. The inclusion of unnecessarily large areas of normal tissues within the range of its penetration is followed by a too widespread destructive alteration of these tissues, progressive arteritis and fibrosis, an alteration which has been clearly revealed by microscopical examination. A more successful result can be obtained by seeking an intense action of a more limited range.

Such can be obtained by using lightly filtered emanation over all superficial lesions and on the superficial portions of the more advanced growths. The strongly filtered emanation must be reserved for the central portions of the deeply invading growths and the inaccessible tumors.

The first retrogressions of epidermoid cancer in the lymphatic glands were obtained when the radium was filtered through 2 mm. of lead, and these results on the glands were made far more complete by the distance application of packs

made of applicators of this thickness of lead. It is true that many of these retrogressions have since been proved by recurrence to have been incomplete, and the attempt to push the dosage has been followed by such severe deep radium effects that this method of dealing with the glands is no longer regarded with the same confidence. Nevertheless the experience gained with it has demonstrated the increased effectiveness of the principle.

The gradual adoption of these methods, far more uniformly penetrating the depth of cancer tissue, has not been accomplished without accidents. It was not at first understood that the theoretically calculated possible increase of the time of exposure of the radium more heavily filtered or further removed from the skin was safe; nor was it appreciated that the effects from overdosage of more heavily filtered radium were far deeper and more profound, slower in their development, and more indolent in their course.

A number of the esophagus and mouth cases and particularly one of the penis cases furnish illustrations of the loss of a much better palliative result, due to the ignorance of these considerations. No more important warning can be upheld to users of radium, when attempting to alter their technic in the direction of a more penetrating ray, than the necessity of increasing the exposures with the greatest caution. The disastrous effects of overexposure are so serious, and they inflict on patients already pitiable so much additional suffering, that too great care cannot be taken to avoid it. It takes at least two or three months to know the full consequences of some of these more deeply penetrating exposures, and before the operator is aware of it, he will be deeply regretting the fact that instead of relieving suffering he has increased it.

Another factor which seriously affects the question of dosage is the alteration produced in normal tissue by one exposure to radium, even though this exposure has produced no objective indications of such an alteration. There can be no longer any doubt that one exposure, even though it has produced no burn, produces some progressive prolonged alteration in not only the skin, but the deeper tissues as well; and this alteration will not permit them to bear so well a second exposure.

In our experience overdosage has more frequently been due to the failure to fully appreciate this fact, and therefore, to the

too frequent repetition of appropriate curative doses on patients with lesions too far advanced for successful radium therapy. While the normal tissues are more easily injured by a repetition of the treatment, the carcinoma cells do not seem to be affected more easily, at least to a proportional degree. In fact, during a series of treatments which have fallen short of producing a satisfactory retrogression, there seems to be produced such an alteration of the primary relations of the normal and cancerous cells to the influence of radium radiations, that there is an approach to the same degree of susceptibility, if not an actual reversal of the primarily existing relative susceptibilities of the normal and cancerous cells to the influence of radium. This fact becomes, however, far less apparent the milder the treatments, and there can be no doubt that in many forms of advanced cancer much palliative relief can be obtained from small dosage. Nevertheless the alteration in susceptibility of the normal tissues is such an important difficulty in the cure of cancer by repeated applications of radium, that it makes it most desirable to secure the maximum effect from the first treatment. In our best cases the retrogressions have been produced by a single treatment. It is not always possible, however, to give a sufficient dose in one treatment, in the case of many tumors, and it is, of course, necessary to keep the first treatment below the burning dosage. In many of these cases it is possible to give a successful treatment in two doses. The greatest caution must be exercised, however, in continuing the repetition of doses which are given with the intention of producing a cure.

Inside the mouth and on mucous membranes generally, unless a fairly complete retrogression can be obtained in a few doses, it is questionable whether it is desirable to undertake the treatment of the case at all. The production of a partial retrogression by an incomplete treatment has never, in our experience, lengthened the course of the disease, and has, in a number of cases, greatly increased the suffering. There has been no retardation of the cancer cells in the periphery of the region affected, and those inside this region have been restrained in their growth, it is true, but this restraint has been accompanied with the formation of a very dense tissue, in part fibrotic, and in part a more indolently growing cancerous tissue. This dense tissue presses severely upon the terminal nerves to the region, and causes a very severe pain.

Much the same rule applies to the treatment of deep masses of large cancers by surface application, but here, by the judicious use of moderate dosage, much palliative relief may be obtained. If, however, heavy dosage is given with the idea of producing a more complete retrogression, and the necessity arises for a repetition of the treatment, the second application should be less severe, and further treatment given only for palliative objects alone. If heavy dosage is persisted in with the idea of producing a cure, the deeper tissues will become transformed into a dense fibrous tissue, which is not only very painful, but may actually cause death. We have seen death follow such an application without the production of any skin ulceration, and with the entire disappearance of the tumor in the neck (Case A. Hosp. No. 23341).

It is a matter of much importance before administering treatment to determine how energetically the first treatment should be pushed. If the prospect of a complete retrogression is tangible, it is permissible to push the first treatment to a point which may be followed by a temporary period of some discomfort. On the other hand, in the case of growths which do not offer the prospect of a favorable course, it is far wiser in some instances to either omit treatment or to administer palliative treatment. The ability to select these cases forms the most important part of the training of the radium worker.

Among the long series of unbenefited cases in this report there have been far too many who, instead of being benefited, have been made worse by attempting to accomplish the impossible with them. The failure to exclude inappropriate cases from treatment, or at least from anything more than the mildest palliative treatment, will only make the cost in human suffering too great to justify the use of radium in cancer.

As regards dosage, the following suggestions will cover the routine applications:

Sixty millicurie-hours per tube will constitute a safe dose when small areas of 1 to 5 sq. cm. are covered, the filtration being through 1 mm. of rubber-covered platinum tubes. If it is through 2 mm. of rubber-covered lead it may be increased to 100 m.c.-hrs. per tube. Through 0.5 of German silver 30 m.c.-hrs. per tube may be given. Such dosage will be curative to superficial, circumscribed lesions, will not cause an objection-

able degree of radium inflammation, and wil lbe curative to superficial small cancers.

Thirty millicurie-hours will constitute a safe dose, when larger areas are covered. (See case M. E. Hosp. No. 24094.) When the 2 mm. lead plaques are used 300 m.c.-hrs. may be applied per sq. cm.

For deep penetration 10,000 to 12,500 m.c.-hrs. may be applied per 100 sq. cm., filtered through 2 mm. of lead, and at a distance of 6 cm. A second dose may be applied at an interval of five weeks, and should be reduced to 8,000 m.c.-hrs. Two such treatments will cause the retrogression of susceptible carcinoma without a serious change in the normal tissues. It is, however, unwise to repeat the treatment, except in a mild palliative way. A still more efficient dose is 18,000 m.c.-hrs. at a distance of 10 cm. from the same area. If this is done, subsequent doses should be reduced to 5,000 m.c.-hrs., unless a very long interval has elapsed and the tissues have entirely resumed their normal appearance. In this case 8,000 m.c.-hrs. may again be used. Centrally placed strong application, filtered through tumor tissue, may vary from 500 to 1,200 m.c.-hrs. over superficial areas of 5 sq. cm. (see case M. B. Hosp. No. 24102), or from 75 m.c.-hrs. per centimeter in the case of rectal tumors, to 300 m.c.-hrs. in the prostate, or 1,200 m.c.-hrs. per centimeter in the cervix uteri.

THE RESULTS OF TREATMENT

In considering the results of treatment it must be borne in mind that no attempt has been made to exclude the more unfavorable cases. Practically all cases applying for treatment have been treated, in part, for the purpose of testing out how far radium can be of palliative benefit. But even upon the earlier and more favorable cases many of our results are poorer than it would be possible for us to obtain at the present time. The details of treatments are specified as follows: First the date, then the form of applicator, the number of millicuries, the filtration, and last the duration of the treatment.

Carcinoma of the Lip

Carcinoma of the lip is usually discovered early. Only those patients who have been treated under a wrong diagnosis for

syphilis, or subjected to delay by the use of local applications or electrical cauterization, etc., present themselves with advanced lesions. There should be no excuse for a failure on the part of the profession to obtain carcinoma of the lip in an early stage. The operative results in carcinoma of the lip are for this reason good. Of the 25 cases which we have treated, we have obtained a clinically complete retrogression in 6. In all 6 patients the growth was in an early stage. In 2 of them it was so superficial and circumscribed that it could have been termed precancerous. This fact, however, does not diminish the importance of the result obtained, but only emphasizes the desirability of treating all patients in this early stage by radium—a stage in which radium performs its best service.

A summary of the clinical records of the two early cases is as follows:

Case R. O'C. Male, 54 years old.

Very early primary epithelioma of the lower lip. Disappeared after a single application of radium.

Condition on Admission, January 27, 1916.—A small ulcer 3/8 inch in diameter upon the vermillion border of the lower lip, just to the left of the middle line. The ulcer is a very superficial one, but the borders are slightly raised and characteristic of epithelioma. It was considered unwise to remove a portion of the tissue for microscopical section.

History.—Four years ago a small ulcer scabbed over, healed and again scabbed over at the site of the present lesion.

Treatment.

Jan. 27, 1916: 1 plaque; 50 m.c.; 1 mm. silver covered with rubber; directly to ulcer; 6 hrs.

The treatment was followed by a complete retrogression of the ulcer, so that the lesion appeared healed on March 1, 1916.

Feb. 13, 1917: No evidence of disease present.

Case C. C. Hosp. No. 23827. Male, 48 years old.

Epitheliomatous erosion of the lower lip, apparently healed.

Condition on Admission, October 20, 1916.—On the left side of the middle line of the lower lip are two superficial, irregularly shaped ulcers. One of these is 1/2 inch in diameter, the other 1/3 inch. The border is very slightly raised and indurated.

There is no submucous infiltration. No lymph nodes are palpable. The removal of a portion of the tissue for microscopical section was considered unwise; but the malignant character of the lesion was confirmed by the conference of the medical board of the hospital by its clinical characters which were clear cut.

History.—Four years ago a scab or crust appeared at the site of the present ulcer. He applied various ointments to the lesion without benefit. Two years ago he gave up smoking, though before this time he had smoked heavily. The ulcer then healed, but reappeared after the resumption of smoking.

Treatment.

Oct. 20, 1916: 3 tubes; 82 m.c.; 1 mm. rubber-covered platinum; to lip; 4 hrs.

Dec. 11, 1916: Lesion entirely healed. No evidence of disease at the present time.

Feb. 13, 1917: Lip still healed.

Summaries of the clinical records of the four epitheliomata of the lip of larger size which have been healed are as follows:

Case N. N. Hosp. No. 22251. Male, 74 years old.

Primary epithelioma of the lip, treated by one centrally placed tube and the administration of a strong dose. Complete disappearance.

Condition on Admission, July 7, 1915.—Surrounding the right angle of the mouth is a semicircular mass of indurated tumor tissue, ulcerated in its center. The growth involves about 1 inch of both the upper and lower lip, and is ¾ inch in transverse diameter. There are no glands palpable in the submental space, but a small pea-sized gland can be felt in the right submaxillary space. The growth was typical of epithelioma and the removal of tissue for microscopical section was not done.

History.—The ulceration which has since developed into the present lesion was first noticed in Jan., 1915. Opposite the ulcer a decayed tooth with a ragged edge had irritated the lip for a long time. The patient had smoked a pipe but not excessively. His previous health has been good.

Treatment.

July 19, 1915: 1 tube; 100 m.c.; 0.6 mm. silver covered with rubber; in the center of ulcer; 12 hrs.

Oct. 6, 1915: The lesion has undergone an apparently complete retrogression.

Nov. 29, 1916: No evidence of disease present.

Feb. 1, 1917: Letter stating that his lip is still well.

Case G. F. Male, 60 years old.

Epithelioma of the lower lip, apparently healed.

Condition on Admission, October 30, 1915.—Upon the left half of the lower lip is an ulcer ¾ inch wide by 1 inch long. The ulcer is indurated, with everted, hard borders, and a nodular, irregular surface. The lesion is typical of epithelioma.

Mx: Epidermoid carcinoma.

History.—The ulcer was first noticed one month ago, when it was covered with a scab. Since then it has gradually grown to the present size. He has smoked a clay pipe constantly. His previous health has always been good.

Treatment.

Oct. 30, 1915: 1 plaque; 50 m.c.; 1 mm. silver and rubber; to lip; 6 hrs.

Following this treatment there was a rapid, apparently complete, retrogression of the lesion, so that in one month's time it was entirely healed. The patient was a very ignorant man, and failed to return for observation, and in his case this fact indicates that there was no return of his disease.

Case G. MacK. Male, 54 years old.

Early epithelioma of the lower lip, healed by two applications.

Condition on Admission, November 15, 1915.—In the middle of the right half of the vermillion border of the lower lip is an indurated nodule, ½ inch in diameter and ¼ inch high.

Mx: Papillary epithelioma.

History.—Three months ago a small nodule the size of a pin head appeared at the site of the present lesion, and has gradually developed into it. He smokes only moderately. He denies syphilis. His previous health has always been good.

Treatment.

Nov. 15, 1915: 1 plaque; 75 m.c.; 1 mm. silver and rubber; to inner side of lesion; 4 hrs.

Nov. 15, 1915: 1 plaque; 75 m.c.; 1 mm. silver and rubber; to outer side of lesion; 4 hrs.

Dec. 21, 1915: The induration has disappeared and the lesion appears healed.

Feb. 1, 1917: Letter stating that there has been no return of disease on the lip.

Case F. L. Hosp. No. 22980. Male, 45 years old.

A fairly well advanced epithelioma of the lower lip, healed by one unnecessarily severe application.

Condition on Admission, March 14, 1916.—Crossing the middle of the left half of the vermillion border of the lower lip is a deep crack, ½ inch long. The edges of the crack are hard and rolled out. The base is hard and forms a tumor 2 by 1 cm. One small gland is palpable in the submaxillary space.

History.—The first trace of the present lesion was noticed in Sept., 1915. He has been a heavy smoker. His previous health has been good.

Treatment.

Mar. 14, 1916: 1 tube; 100 m.c.; 1½ mm. platinum and rubber; to crack in lip; 12 hrs.

½ plaque; 100 m.c.; 3 mm. lead and rubber; to outside of lip; 12 hrs.

Jan. 1, 1917: A considerable and painful reaction, lasting six weeks, followed this treatment, when the lesion healed and has remained well ever since.

Of the remaining 19 patients with cancer of the lower lip, 6 were very considerably improved, one is still under treatment, and 12 were very slightly or not at all improved. All of these 12 patients had advanced or recurrent lesions.

The following is a summary of the clinical record of one of the five improved patients:

Case A. M. Hosp. No. 23177. Male, 70 years old.

Recurrent epithelioma of the lip. Complete retrogression of this lesion, but recurrence in the submaxillary lymph nodes.

Condition on Admission, August 21, 1915.—There is a shallow defect of the right half of the lower lip, in the center of

which is a vertical scar. In the scar and toward the right extremity of the defect are indurated nodules.

History.—The patient states that since he was a boy there has been a scaly spot upon the lower lip. This has healed and ulcerated from time to time. In 1902 the scaly spot became a definite ulcer, with suspicious borders. It showed a tendency to progressive increase in size. This was excised and remained well for 13 years. It then (1½ years ago) recurred, and was treated with *x*-rays, and finally by this treatment healed. In March, 1915, it recurred, and was treated by the electric needle and *x*-rays. The patient denies syphilis, does not indulge in alcohol, but has been a heavy smoker up to two years ago.

Treatment.

Aug. 21, 1915: 1 tube; 50 m.c.; 0.6 mm. silver, covered with rubber; to lip; 1 hr.

Aug. 26, 1915: 1 tube; 100 m.c.; 0.6 mm. silver, covered with rubber; to lip; 8 hrs.

Oct. 27, 1915: The ulcer now measures ⅜ by ½ inch. There is still some induration present, but retrogression is still proceeding.

Nov. 10, 1915: 2 tubes; 100 m.c.; 0.6 mm. silver, covered with rubber; to lip; 6 hrs.

Nov. 10, 1915: 2 plaques; 200 m.c.; 1 mm. silver and rubber; to skin surface of the lip; 6 hrs.

Following this treatment there was a severe radium inflammation.

Feb. 8, 1916: The slough has separated, and only a small indurated nodule at one corner remains. The submaxillary lymphatic has increased in size.

May 8, 1916: 6 plaques; 600 m.c.; 1 mm. rubber-covered lead; to neck; 8 hrs.

(?) tubes; 115 m.c.; 1 mm. rubber-covered platinum; to lip; 4 hrs.

Jan. 10, 1917: No evidence of disease in the lip, but in the right submaxillary space there is a large discoid prominence about 2½ inches in diameter at its base. It is fixed to the deeper parts, but the skin is freely movable over it. There is a small gland in the opposite side of the neck. The patient failed to return to the hospital since his last treatment, having considered himself cured.

Jan. 11, 1917: 12 plaques; 756 m.c.; 2 mm. lead; 2 cm. gauze; to right side of neck; 12 hrs.

The following is a summary of one of the unimproved cases of cancer of the lower lip:

Case J. J. Male, 54 years old.

Very advanced cancer of the lip, previously treated with *x*-rays. Two strong treatments by radium from one tube in each case. This produced no change in the progress of the disease.

Condition on Admission, June 22, 1915.—At the left angle of the lower lip there is a large defect lined with epitheliomatous tissue. The defect is ½ inch in diameter and it is surrounded with indurated tissue which involves the alveolar process of the lower jaw and the adjacent portion of the buccal surface of the cheek as far back as the bicuspid teeth. The submaxillary glands are involved.

History.—Eight or ten years ago his lip was cut with glass. Two years ago a small epithelioma, the size of a bean, was excised from the left corner of the lower lip. Eight months ago a recurrence of the growth was treated with *x*-rays. The lesion increased in size under this treatment. The patient's previous health has always been good. He has smoked but only in moderation.

Treatment.

June 22, 1915: 1 tube; 50 m.c.; 0.6 mm. silver covered with rubber; to inside of mouth; 12 hrs.

1 plaque; 200 m.c.; 1 mm. silver covered with rubber; externally; 12 hrs.

Since this treatment there was at first a temporary improvement, but finally a progressive increase in the ulceration, and death on Feb. 16, 1917.

All but one of the 12 unimproved patients had recurrent lesions, and the one exception presented on admission a lesion 3 inches in diameter and involving the central two-thirds of the vermillion border of the lower lip and the whole of the vertical diameter of the lip.

The conclusion appears entirely justified that an unsuccess-

ful operation, though followed at first by a small recurrence in no way diminishes the age of a carcinoma. The remaining disease often appears to grow more actively as a result of the operation. The carcinoma cells which have passed beyond the plane of excision find conditions more favorable to growth in the new connective tissue spaces, the distribution of the disease is exactly as widespread as if its center, so to speak, had not been removed, and death comes as quickly, if not more quickly, than if operation had not been performed. Sticker * offers evidence to show that in the lower animals the presence of a primary growth exerts a restraining influence upon the same tumor elsewhere.

Technic of the Application of Radium to the Lip

Carcinoma of the lip is best treated by the use of sufficient tubes to not only cover the entire lesion, but a zone of apparently healthy tissue around the lesion. The platinum tubes of one millimeter in thickness, covered with rubber and fastened together by adhesive plaster, or tied to a piece of gauze, may be wrapped over the vermillion border, in this manner surrounding the whole lesion and including a portion of the internal and external surface of the lip. Both the lesion and some of the thickness of the lip below the lesion will be subjected to a cross fire. The tubes used in this manner form a very light applicator, a necessary form to use upon the lip. The whole applicator may be held in place by a gauze pad or packing placed inside the mouth and over the applicator, between it and the upper lip. This pad serves also the important function of separating the upper lip and the tongue or cheek, thus preventing a burn upon these mucous membranes.

Nasal Mucosa

Three patients with epithelioma of the nasal mucosa were treated. Two of these were not improved. Both patients had advanced recurrent lesions. The difficulties of making accurate applications to the nose are very great, and unless the lesion is an early one and low down, a satisfactory application cannot

* *Zeitschr. für Krebsforsch.*, 1911, x, 103, xi, 97.

be made to a growth of the nasal cavity without a removal of the lateral wall of the nose.

In one of the two patients treated the growth was from the septum and the floor of the nasal passage. It was treated by introducing tubes of radium inclosed in one rubber tube, and introduced from before backwards through the nasal passage, a method which has been very successful in some lymphosarcomata of the nose and nasopharynx.

In the second patient an attempt was made to render the growth more accessible by resecting the lateral wall of the nose. It was soon appreciated that the growth involved the upper part of the nasal cavity, and the internal wall of the orbit was not removed. The growth was most malignant, rapidly invading the frontal sinuses and causing death from necrosis of the frontal bone and suppurative meningitis after a total duration of five months from the time that the disease was first noticed.

A third patient with a recurrent epidermoid carcinoma of the posterior portion of the nasal septum has given to date an excellent result. The tumor occluded both nasal passages. It was first removed with a snare and then the base treated with radium.

The patient has been greatly relieved and to date, an interval of three months, there has been no recurrence.

Cancer of the Superior Maxilla

Twenty-seven patients with cancer of the superior maxilla have been treated. Four of these have undergone a retrogression which is clinically complete. In each case the lesion was epidermoid carcinoma. Two of these patients are of much interest because of the long time during which they have now remained well. In both cases the diagnosis was demonstrated by microscopical section. The clinical record of these patients is as follows:

Case D. MacN. Hosp. No. 21666. Female, 32 years old.

Recurrent epithelioma of the superior maxilla; recurrence in the scar of the face. Complete retrogression following one treatment.

Condition on Admission, November 13, 1914.—A small flattened rather soft tumor is present beneath the eye and to the

side of the nose, in the line of the scar on the anterior surface of the cheek. This scar is the usual one left after the typical incision for the resection of the superior maxilla, which has been partially removed.

Mx: Epidermoid carcinoma.

Microscopical section showed epidermoid carcinoma.

History.—In Oct., 1912, a tumor grew from the anterior wall of the antrum, producing a swelling on the cheek. An attempt was made to remove this by a local resection. It recurred and in Apr., 1913, the attempt was repeated, the anterior wall of the antrum being resected. The lymphatic glands of the neck then became enlarged, and in July, 1913, and Sept., 1913, they were excised by a block dissection of the neck. The above described recurrence in the scar of the face first appeared two weeks ago.

Treatment.

Nov. 13, 1914: 1 plaque; 25 m.c.; 1 mm. rubber-covered lead; directly; 15 hrs.

Following this treatment there was a rapid disappearance of the lesion, and on

May 3, 1916: No evidence of recurrence in the neck or locally.

Feb. 13, 1917: No evidence of disease.

Case M. C. Hosp. No. 22203. Male, 65 years old.

Advanced recurrent epithelioma of the superior maxilla. A clinically complete retrogression when last seen, four months after treatment.

Condition on Admission, July 1, 1915.—Examination reveals an ulcerated mass of neoplastic tissue, presenting an irregular worm-eaten surface and extending from before backward upon the external wall of the antrum, the inferior and internal walls of which have been resected. The neoplasm involves the entire thickness of the tissues of the cheek, producing an ulcerated mass externally 1 inch in diameter and raised ¼ inch.

History.—The growth was first noticed three and a half years before admission as a small ulcer upon the upper left alveolar process. Two years ago an attempt was made to completely remove the growth by the resection of the alveolar

process. He first noticed a recurrence two months ago, both inside the mouth and externally upon the cheek.

Treatment.

July 6, 1915: 1 tube; 100 m.c.; 0.6 mm. silver covered with rubber; internally; 12 hrs.

1 plaque; 75 m.c.; 1 mm. silver covered with rubber; externally and directly; 12 hrs.

Sept. 1, 1915: 1 tube; 100 m.c.; 0.6 mm. silver covered with rubber; internally; 8 hrs.

Nov. 10, 1915: Progressive improvement had taken place to date. At present no sign of disease remains.

It has been impossible to trace the patient since this time.

Case T. T. Hosp. No. 22731. Male, 29 years old.

An advanced recurrent epithelioma of the antrum. Apparently healed by three applications.

Condition on Admission, August 11, 1915.—An ulcerated nodular mass about ¾ inch in length by ⅜ inch in width is growing from the anterior portion of the upper wall of the antrum. The remaining walls of the antrum have been removed by operation about the middle of April, 1916.

Mx: Epidermoid carcinoma.

History.—In March, 1915, a swelling appeared external to the first molar tooth on the alveolar process. This increased in size and the superior maxilla was resected in April.

Treatment.

Aug. 11, 1915: 1 tube; 100 m.c.; 0.6 mm. silver covered with rubber; directly; 8 hrs.

Sept. 1, 1915: Marked clinical retrogression of the lesion.

Sept. 25, 1915: 1 plaque; 200 m.c.; 1 mm. silver and rubber; directly externally; 12 hrs.

Sept. 25, 1915: 1 tube; 50 m.c.; 0.6 mm. silver and rubber; internally; 6 hrs.

Nov. 3, 1915: Continued retrogression.

Nov. 16, 1915: Small ulcer has developed upon the internal surface of the middle turbinated bone.

Nov. 17, 1915: 3 tubes; 75 m.c.; 0.6 mm. silver and rubber; one to the new ulcer, others to external wall of antrum; 5 hrs.

July 26, 1916: No evidence of disease.

Feb. 13, 1917: No evidence of disease.

Case M. S. Hosp. No. 23773. Male, 47 years old.

Epithelioma of the superior maxilla, apparently removed by three applications.

Condition on Admission, September 24, 1916.—Projecting from the groove formed by the reflection of the buccal mucous membrane upon the superior alveolar process of the right side is an egg-shaped mass, 1 x 1½ inches in diameter. The tumor consists of one mass. It is relatively soft and bleeds easily when traumatized. It produces a discoid prominence of cheek over the anterior antral wall.

Mx: Epidermoid carcinoma.

History.—The disease was first noticed 6 weeks ago. He consulted a dentist, who pulled one tooth in the neighborhood of the tumor. The three remaining teeth on the upper jaw are mere stumps. For years he has neglected his teeth, but they have never pained him. He is a heavy smoker (10 cigars a day). He denies syphilis. His general health has always been good.

Treatment.

Sept. 24, 1916: 9 tubes; 225 m.c.; 1 mm. platinum, covered with rubber; directly on mass; 6 hrs.

Nov. 9, 1916: There is a complete disappearance of the ulceration and tumor mass inside the mouth. The swelling upon the face has been transformed into a fluctuating prominence.

Nov. 13, 1916: 12 tubes; 540 m.c.; 3 mm. lead, 2 cm. wood; to face; 12 hrs.

Nov. 27, 1916: Excision of the superior alveolar process on the right side, thus opening the antrum, which was filled with soft tumor tissue.

Dec. 19, 1916: The extensive swelling has entirely disappeared. Inside the mouth the lesion seems to have disappeared.

Dec. 19, 1916: 6 tubes; 228 m.c.; 1 mm. platinum covered with rubber; in antrum; 2 hrs.

Jan. 17, 1917: No evidence of disease present. Minute nodules in the submaxillary space.

Feb. 13, 1917: No evidence of disease.

Eleven patients with epidermoid carcinoma of the superior maxilla have been considerably improved. Of these two are still under treatment, and both promise well.

The following clinical record illustrates the course of one

of the patients classified as improved. It illustrates a number of important facts relative to the use of radium:

1. An initial very favorable effect upon a large inoperable growth of the superior maxilla which was growing rapidly and threatened to soon end life.

2. A disappearance of metastatic lymph nodes after radiation.

3. The risk in not exposing the cavity of the antrum immediately after the first effect of radium treatment in the case of growths involving the superior alveolar border.

4. Finally the danger from a persistence of the treatment of cancer by radium when once the disease begins again to make headway, after having been incompletely controlled by the first treatments.

Case L. D. Hosp. No. 22703. Female, 50 years old.

Advanced carcinoma of the superior maxillary alveolar process. Considerable improvement for a period of a year, until a final treatment produced extensive sloughing and hastened death.

Condition on Admission, September 27, 1915.—Within the mouth a large, soft, easily bleeding, partly necrotic mass, approximately two inches in diameter, covered the right superior alveolar process and filled the space between this process and the cheek, which was bulged forward by it. Radiograph shows a diffuse destructive process of the superior maxilla, with displacement of nasal septum to the left and very irregular bony outlines.

Mx: Section taken July 17, 1916, showed fully developed epidermoid carcinoma.

History.—On June 12, 1915, the right eye became inflamed, so that she thought a splinter had gotten into it. This attack subsided in four to five days. Soon afterwards a small, tender lump appeared in the region of the lachrimal duct. In July the upper teeth on the left side became painful, and were extracted. On Aug. 20, 1915, the antrum was explored, but no pus was found.

Treatment.

Sept. 27, 1915: 1 tube; 100 m.c.; .6 mm. rubber-covered silver; within mouth; 8 hrs.

Sept. 27, 1915: 1 plaque; 150 m.c.; 1 mm. rubber-covered silver; externally; 12 hrs.

Nov. 18, 1915: 1 tube; 50 m.c.; 1 mm. rubber-covered silver; internally; 6 hrs.

Nov. 18, 1915: 1 plaque; 100 m.c.; 1 mm. rubber-covered silver; externally; 6 hrs.

Jan. 4, 1916: No definite evidence of disease present.

Feb. 2, 1916: Recurrence of tumor, causing bulging of the face.

Feb. 2, 1916: 2 plaques; 350 m.c.; 3 mm. lead ½ inch distant; to face; 12 hrs.

Mar. 2, 1916: Small tumor bulging into the nasal passage from the right lateral nasal wall.

Mar. 2, 1916: 1 plaque; 100 m.c.; 1½ mm. platinum; directly in nasal cavity; 8 hrs.

Mar. 24, 1916: Following these treatments the patient had much pain, due to the radium. An enlarged lymphatic gland was palpated in the neck, and the patient's nutrition has suffered much.

Mar. 24, 1916: 3 plaques; 300 m.c.; 3 mm. lead; directly to neck; 8 hrs.

July 1, 1916: 3 tubes; 30 m.c.; 1 mm. platinum; internally; 2 hrs.

10 plaques; 1,100 m.c.; 3 mm. lead, 2 cm. wood; to face; 4 hrs.

July 22, 1916: 3 tubes; 30 m.c.; 1 mm. platinum; internally; 6 hrs.

Aug. 4, 1916: Some swelling in the face. General condition very poor. Has been able to eat very little. The pain is largely relieved. Considerable swelling over the zygomatic region and much tumor tissue appearing on the exterior of the cheek; within the cavity of the antrum more tumor tissue present.

Oct. 1, 1916: 5 tubes; 170 m.c.; 1 mm. rubber-covered platinum; to cavity of antrum; 6 hrs.

Oct. 4, 1916: 12 plaques; 780 m.c.; 3 mm. lead, 2 cm. wood; over face; 12 hrs.

Nov. 2, 1916: Whole condition has been much improved by the last treatment, the tumor tissue inside has retrogressed and the swelling of the face diminished.

Dec. 1, 1916: The general condition is fast deteriorating, and the pain increasing.

Death occurred on Dec. 19, 1916. A few days before death the region treated, including the contents and a portion of the walls of the pterygo-maxillary fossa sloughed out. There has been no recurrence in the glands of the neck.

One patient was treated prophylactically after operation for epithelioma of the posterior portion of the superior alveolar process, performed on Feb. 4, 1916. He is still free from disease.

Nine patients with epithelioma of the superior maxilla have been only slightly or not at all improved. Six of these patients had extensive recurrences after previous operation. The three other cases had very large growths when first treated. The first of the two following case records is illustrative of the course of one of these advanced lesions following treatment. It is a most instructive case, particularly when contrasted with the case record of a very similar condition, although occurring in a somewhat younger and stronger person: the second of the two following case records.

Case S. U. Hosp. No. 23331. Male, 53 years old.

A very large epithelioma of the superior maxilla, massive dose of radium applied directly to the surface of the skin. A practically complete disappearance of the tumor, but death of the patient in four months' time from necrosis and infection of tissues of face.

Condition on Admission, February 8, 1916.—A prominent swelling of the left cheek produced by a mass, evidently springing from the antrum and producing an enlargement of the upper left alveolar process and ulceration of its mucous membrane; no cervical lymphatics palpable.

Mx: Microscopical section showed typical epidermoid carcinoma.

History.—He first noticed the trouble six months ago, when ulceration and swelling of the alveolar process and loosening of the upper teeth of the right side developed. This condition gradually grew into the present one.

Treatment.

Feb. 8, 1916: 6 plaques; 545 m.c.; 3 mm. rubber-covered lead; externally; 22 hrs.

2 tubes; 150 m.c.; 0.6 mm. silver covered with rubber; internally; 8 hrs.

Following this treatment there was a gradual disappearance of all the tumor tissue, but with it the general condition of the patient gradually deteriorated from necrosis and infection of tissues of face. Considerable deep pain was felt, and the patient died June 18, 1916, without evident recurrence, in a condition of general asthenia.

Case A. H. 23612. Female, 45 years old.

Bulky inoperable epithelioma of the antrum. Treated at first with very small doses frequently repeated, with indifferent success, and later with one large dose with the production of an incomplete, but very pronounced, objective improvement, but increase of pain.

Condition on Admission, August 13, 1916.—The left side of the face over the anterior wall of the antrum is protruded forwards by a hard and somewhat nodular tumor, measuring 4½ inches across its base. It fills the space between the nose, upper lip and eyelid, displacing the nose from beneath toward the opposite side, and obstructing the left nasal cavity. The left eye is almost closed. Within the mouth a nodular ulcerated mass of neoplastic tissue has destroyed the alveolar process and the hard palate. It protrudes into the mouth, having filled the antrum and part of the left nasal cavity. No enlarged lymphatic glands are discovered.

Mx: Epidermoid carcinoma.

History.—Nine months ago she first noticed the swelling in the cheek. The teeth of the upper left side of the jaw were extracted. The tumor continued to grow.

Treatment.

Aug. 18, 1916: 2 tubes; 36 m.c.; 1 mm. platinum and rubber; within the mouth; 2 hrs.

Aug. 23, 1916: 2 tubes; 30 m.c.; 1 mm. platinum and rubber; within the mouth; 3 hrs.

Aug. 26, 1916: 3 plaques; 90 m.c.; 3 mm. rubber-covered lead; to face; 2 hrs.

Sept. 8, 1916: 3 plaques; 150 m.c.; 3 mm. rubber-covered lead; to exterior of face; 1½ hrs.

Sept. 18, 1916: 12 plaques; 600 m.c.; 3 mm. rubber-covered lead; to exterior of face directly; 2½ hrs.

Sept. 18, 1916: Within the mouth to date there had been some superficial improvement. There is a little less tumor tissue. The swelling of the face, however, is steadily increasing in size, so that the left eye is now completely closed.

Oct. 4, 1916: 12 plaques; 660 m.c.; 3 mm. rubber-covered lead, 2 cm. gauze; over the surface of the tumor; 12 hrs.

Oct. 25, 1916: 7 tubes; 240 m.c.; 1 mm. platinum and rubber; within the mouth; 1½ hrs.

Nov. 1, 1916: 12 plaques; 720 m.c.; 3 mm. lead, 2 cm. wood; to face; 12 hrs.

Since the application on Oct. 4th there has been a steady diminution of the size of the tumor on the face. This diminution in size, however, has been accompanied with the development of severe pain referred to the region of the tumor.

Jan. 9, 1917: The pain has become so severe that the following treatment is prescribed for palliative relief:

Jan. 9, 1917: 12 plaques; 480 m.c.; 2 mm. lead, 3 cm. distant; to face; 10 hrs.

Following this treatment there has been no particular change in the patient's condition.

Both these patients had tumors of approximately the same size and histology. In the first patient, older and more feeble, it is true, a large dose of radium caused an apparent complete retrogression of the disease, but death from the necrosis of tissue.

In the second patient a little more than half the dose received by the first patient, applied, it is also true, a greater distance from the skin, failed to cause a retrogression, though it caused some diminution in the size of the growth and stopped its progressive increase in size. The patient suffered considerable pain for a long time following the treatment, but her general health did not seem to be impaired by the treatment.

The contrast offered by these patients has been practically duplicated in the treatment of large metastatic growths of epi-

dermoid carcinoma in the lymphatic glands of the neck, and will be referred to in connection with these two case reports by way of anticipation.

These metastatic growths in the neck can be made to disappear by a sufficient dosage, which will still be short of an amount causing ulceration of the skin, but only at the expense of serious systemic injury. Smaller doses are free from the systemic injury, but are only rarely followed, in the technic which we use, by complete retrogressions of epidermoid cancer in the neck. The subjective discomfort following such incomplete effects, due in part to the more indolent growth of the carcinoma associated with fibrosis, make the advantage of such results doubtful.

Epithelioma of the superior maxilla is a favorable form of cancer to treat with radium. It responds well and seems to involve the lymphatic glands late. In our experience it most often begins on the alveolar process, not infrequently in connection with the follicle of some tooth.

Whether beginning outside or inside the antrum, this cavity becomes involved early, and it is never safe to allow it to remain closed. Its interior must be exposed by a removal of the alveolar process forming the floor of the antrum.

During the treatment of several patients, after there appeared to be a complete retrogression of the whole lesion as far as could be determined by an examination of the mouth, the antrum was subsequently found filled with tumor tissue. It is unsafe, therefore, in the treatment of epithelioma of the superior maxilla, developing anywhere in relation to the alveolar border or the walls of the antrum, to allow this cavity to remain unexposed.

It is wise to give a preliminary treatment to a tumor of the superior maxilla by folding around the tumor tubes attached to a piece of muslin, and holding such an applicator in place by gauze pads. When the visible portion of the growth shows marked retrogression the antrum should be opened and the interior of its cavity, particularly the tissues on the cheek side of the opened space, should be treated.

This method with its favorable outcome is well illustrated by Case No. 23773 (page 93).

Cancer of the Cheek

Cancer of the cheek offers somewhat the same favorable conditions for treatment by radium as cancer of the lip. It is usually not discovered as early and, more frequently, on account of its concealed position, patients come later for treatment, irrespective of the fact that they may discover their lesions later, than is the case with cancer of the lip.

Cancer of the cheek, however, displays a tendency to remain localized for a relatively long time, invades the glands of the neck earlier than cancer of the superior maxilla, but later than most other forms of cancer of the mouth and, in the cases which we have treated, appears to yield with considerable susceptibility to the influence of radium. The lesions are easily covered with radium applicators made by attaching the radium tubes to muslin cut to an appropriate size to cover the lesion, and retained in place by simply laying them upon the lesion and packing gauze pads against them between the teeth and the tongue.

Four patients with cancer of the cheek have completely retrogressed and are to-day well; one of them has now been so for over two years. The clinical records of these patients is as follows:

Case F. E. Hosp. No. 21433. Male, 68 years old.

Advanced epithelioma of the cheek, cured by a combination of limitation of blood supply, cauterization and radium.

Condition on Admission, June, 1914.—A large epitheliomatous ulcer involves the entire thickness of the right cheek from the left corner of the mouth backwards toward the last molar tooth. Internally the ulcer forms a deep crack, with hard elevated edges. Externally opposite the ulcer there was a prominence produced by the tumor upon the cheek. The skin was adherent and reddened over the summit of this prominence. There was a gland the size of a hickory nut in the submaxillary space.

Mx: Epidermoid carcinoma.

History.—Two years ago the patient first noticed his disease as a small nodule in the right angle of the mouth. This soon

ulcerated and progressively developed into the lesion now present.

Treatment.—He received small doses of radium and *x*-ray treatments from June, 1914, to Dec., 1914. Comparatively little improvement resulted.

After ligation of its superior thyroid and lingual branches, the external carotid was injected with hard paraffin and vaseline. This resulted in a sloughing of all the diseased area and the lobe of the ear. The disease recurred around the upper margin of the defect left by the sloughing process. This recurrence was treated with radium on April 19, 1915. Only 20 m.c. for a period of 20 hours were used in the treatment. The margin was then cauterized away. A second recurrence developed and involved 2 to 4 inches of the upper margin of the hole. This was treated with 200 m.c. applied to the whole upper margin in 1 mm. rubber-covered silver.

Aug. 9, 1915: The patient appears free from disease and pain.

Feb. 13, 1917: Still free from any recurrence.

Case M. N. Hosp. No. 23200. Male, 70 years old.

Epithelioma of the cheek and alveolar border, apparently healed by three applications.

Condition on Admission, April 5, 1916.—The upper, internal and external surfaces of the alveolar process of the lower jaw on the left side is covered with an ulcerated superficial mass of neoplastic tissue. The disease has infiltrated the adjacent portion of the cheek, as high as the superior alveolar process, and the whole thickness of the cheek in the interalveolar portion, producing an ulcer externally one inch in diameter. There are no glands palpable in the neck. The teeth still remaining on the lower jaw are in a very bad condition. None remain in the diseased portion. The teeth on the upper jaw are all present from the central incisor to the second molar.

Mx: Epidermoid carcinoma.

History.—The disease was first noticed one year ago. He has always been a heavy chewer and moderate smoker.

Treatment.

Apr. 15, 1916: 3 tubes; 300 m.c.; 1 mm. platinum covered with rubber; directly; 4 hrs.

May 26, 1916: 2 tubes; 200 m.c.; 1 mm. platinum covered with rubber; externally; 3 hrs.

July 15, 1916: 3 tubes; 82 m.c.; 1 mm. platinum and rubber; internally; 6 hrs.

July 26, 1916: There is a complete retrogression. A few nodes of uncertain significance felt in the neck.

Feb. 13, 1917: Retrogression still complete.

Case L. A. Hosp. No. 23751. Male, 56 years old.

A large epithelioma of the internal surface of the cheek. Apparent complete clinical retrogression following two treatments.

Condition on Admission, September 27, 1916.—Upon the internal surface of the cheek there is an irregular shaped ulcer extending from the right corner of the mouth 2 inches backward to almost the anterior pillar of the fauces. The base and edges are hard and very prominent. Upon the external surface of the cheek, opposite the anterior end of the ulcer, is a round prominence 1½ inches in diameter. The skin over this is adherent and reddened. All the teeth on the upper jaw, with the exception of one, are absent. On the lower jaw, several are present; most of these are in bad condition. One tooth, opposite the anterior end of the lesion, had for a long time badly irritated it. It was extracted 3 weeks ago.

Mx: Epidermoid carcinoma.

History.—He first noticed ulceration on the cheek 6 months ago. It has gradually increased to the present size. He denies syphilis, smokes in moderation, and drinks little. He is married; has three children. No history of cancer in his family. He has locomotor ataxia.

Treatment.

Sept. 29, 1916: 6 tubes; 240 m.c.; 1 mm. platinum covered with rubber; to inside of cheek; 4 hrs.

Sept. 29, 1916: 4 plaques; 192 m.c.; 2 mm. lead, four layers gauze; to outside of cheek; 4 hrs.

Oct. 18, 1916: There is a superficial slough over the area treated outside the mouth, and this is very painful. The induration, however, is about gone, except at the thickest part of the lesion in front, where there is still a small nodule ¼ of the original size.

Treatment.

Nov. 28, 1916: 7 tubes; 210 m.c.; 1 mm. rubber-covered platinum; inside of cheek; 2 hrs.

Nov. 28, 1916: 6 plaques; 450 m.c.; 3 mm. lead, 2 cm. wood, 1 cm. gauze; outside of cheek; 18 hrs.

Jan. 24, 1917: No evidence of disease present. The burn on the cheek is almost healed.

Feb. 13, 1917: Healing complete.

Case J. N. Hosp. No. 24032. Male, 75 years old.

A very superficial epithelioma widely distributed through the mucous membrane of the mouth. Very rapidly retrogressing at present.

Condition on Admission, December 26, 1916.—Covering the inner surface of the left cheek and the whole of the inner surface of the left side of the lower lip and the adjacent and upper surface of the alveolar process of the lower jaw, is a superficial, papillary sessile growth, entirely devoid of evidence of submucous infiltration. Separated from this process is a second patch, about 1½ inches in diameter, and in general circular in shape, and similar in character. This is situated upon the roof of the mouth, in the middle line, covering in part both the soft and hard palate.

Mx: Papillary epithelioma.

History.—The patient first noticed ulceration at the site of the largest lesion seven months ago. It has not been treated, and has gradually increased to the present size. He has been a heavy smoker until the development of the present trouble. He denies syphilis. All his teeth have been extracted.

Treatment.

Dec. 26, 1916: 6 tubes; 200 m.c.; 2-1½ mm. platinum (40 m.c.), 4-1 mm. platinum (30 m.c.) covered with rubber; to cheek; 2 hrs.

Dec. 28, 1916: 7 tubes; 170 m.c.; 1 mm. rubber-covered platinum; to palate; 2 hrs.

Jan. 24, 1917: The lesion on soft palate is entirely cleared up, without any sign of radium inflammation. There is a small remnant of the tumor over the base of the coronoid process and inner surface of the cheek.

Mar. 5, 1917: 10 tubes; 400 m.c.; 1 mm. platinum and rubber; to cheek; 1 hr.

Mar. 20, 1917: Retrogression almost complete.

Three patients with cancer of the cheek are still under treatment. They have all been greatly improved.

Case W. S. Hosp. No. 23676. Male, 69 years old.

An advanced epithelioma of the whole thickness of the cheek. A very considerable retrogression following three treatments.

Condition on Admission, September 2, 1916.—Inside the cheek a crater-like ulcer 1 inch in diameter, which does not involve the jaw. The ulceration extends through the cheek and involves the skin externally. Around the fistula is a lesion ¾ inch in diameter. There are no teeth. No palpable glands in the neck.

History.—He first noticed the trouble ten months ago. Until then he was perfectly well. He has been a heavy smoker, chiefly cigarettes.

Treatment.

Sept. 2, 1916: 9 plaques; 405 m.c.; 3 mm. lead, 2 cm. wood; to left cheek externally; 18 hrs.

Sept. 15, 1916: 2 tubes; 84 m.c.; 1 mm. platinum and rubber; inside of cheek; 8 hrs.

Nov. 7, 1916: Considerable retrogression of the ulcer in the mouth has taken place.

Nov. 7, 1916: 12 plaques; 780 m.c.; 3 mm. lead and gauze; to cheek externally; 18 hrs.

Nov. 14, 1916: 5 tubes; 180 m.c.; 1 mm. platinum and rubber; inside of cheek; 2 hrs.

Jan. 3, 1917: Only slight induration at site of ulcer. Its base still covered with a slough. Some skin irritation over the gland, which was treated externally but gland has disappeared.

Jan. 24, 1917: Internally area of the ulcer is fairly clean, but still there is a deep infiltration of tissues of cheek and ulceration of the external surface of the cheek.

Jan. 28, 1917: 12 plaques; 756 m.c.; 3 mm. lead, 6 cm. distant; to cheek; 6 hrs.

The base of the ulcer on the inside of the cheek is fairly clean and relatively free from disease but externally there is

still deep infiltration of the substance of the cheek indicating that the further course will be unfavorable.

Case C. R. Hosp. No. 23156. Male, 45 years old.

Recurrent advanced cancer of the cheek. Previously treated with indifferent success by small doses frequently repeated. Considerable retrogression following two strong treatments.

Condition on Admission, September 13, 1916.—The jaw can be opened only to a slight extent. The teeth upon the upper jaw are absent with the exception of a few remaining roots anteriorly. The right alveolar process on the lower jaw is absent. Upon the external surface of the right cheek is a deeply excavated ulcer about the size of a half dollar. Its margins are indurated and its base covered with a slough. Small glands are palpable in the right upper carotid region, and the neck shows scarring from previous radium treatment.

History.—Five years ago a small papule-like nodule appeared on the external surface of the right cheek. It increased very little during the next four years. Ten months ago it was excised. In two months a recurrence took place. Since April he has had 16 radium treatments at another institution,—one or two strong treatments externally, the others being short treatments internally. The treatments always caused improvement, but were followed by a recurrence.

Treatment.

Sept. 13, 1916: 3 tubes; 126 m.c.; 1 mm. platinum and rubber; to ulcer inside of mouth; 6 hrs.

9 plaques; 450 m.c.; 2 mm. lead, 3 cm. wood; to face; 18 hrs.

Nov. 30, 1916: 12 plaques; 600 m.c.; 2 mm. lead, 3 cm. wood; to face; 16 hrs.

Jan. 3, 1917: There is some diffuse swelling over the ramus of the jaw and considerable pain, referred to the ear.

Placebo Treatment.

Jan. 3, 1917: 9 plaques; 360 m.c.; 2 mm. lead, 3 cm. wood; to face; 3 hrs.

Apr. 16, 1917: Readmitted. Face very painful. Large ulcer 1½ inches in diameter on the external surface of the cheek. Its base is formed of neoplastic tissue causing a diffuse prominence.

Apr. 16, 1917: 12 plaques; 1200 m.c.; 2 mm. lead, 6 cm. distance; to cheek; 5 hrs.

Apr. 28, 1917: Discharged; unimproved.

Case M. McC. Hosp. No. 23833. Male, 67 years old.

Large epithelioma of the inside of the cheek. Retrogression rapidly progressing to date.

Condition on Admission, October 28, 1916.—On the internal surface of the left cheek is a raised, flattened ulcer, ¼ inch high and 1½ inches in diameter. The base is indurated and covered with small neoplastic nodules, and the margins everted, hard and nodular. In the left submaxillary space there are small pea-sized nodules. On the left side of the face, over the prominence of the malar bone, at a higher level than the lesion on the inside of the cheek, and having no connection with the internal lesion, is a typical cutaneous epithelioma, involving an area of the skin 1 inch in diameter, and consisting of three separate nodules with cicatricial tissue between them.

Mx: Epidermoid carcinoma.

History.—He first noticed ulceration on the internal surface of the cheek six months ago. It gradually increased to the size of the present lesion. His general health has always been good. He is a moderate smoker and drinker. The cutaneous epithelioma on the outside of the cheek represents a recurrence from a previous lesion excised from the face seven years ago.

Treatment.

Oct. 28, 1916: 7 tubes; 210 m.c.; 1 mm. platinum and rubber; to ulcer on inside of cheek; 2 hrs.

Dec. 9, 1916: 7 tubes; 161 m.c.; 1 mm. platinum and rubber; to ulcer on inside of cheek; 2 hrs.

Dec. 13, 1916: The lesion is about one-half its original size.

Jan. 20, 1917: 8 tubes; 160 m.c.; 1 mm. platinum and rubber; to ulcer on inside of cheek; 1 hr.

Mar. 23, 1917: Readmitted. The base of the ulcer on the inside of the cheek is fairly clean but there is a deep infiltration anteriorly of the lips and substance of the cheek.

Mar. 23, 1917: 8 tubes; 256 m.c.; 1 mm. platinum, 16 layers of cotton; to ulcer; 4 hrs.

Mar. 25, 1917: 12 plaques; 600 m.c.; 2 mm. lead, 4 cm. distance to face; 15 hr.

Apr. 9, 1917: Severe radium reaction.

One patient with cancer of the cheek has been treated prophylactically following operation. He is still well, but has been treated too recently to permit of any conclusion upon the effect of the treatment.

Three patients with carcinoma of the cheek have not been benefited by the treatment. Two of these patients had hopelessly advanced lesions when they were admitted for treatment. The third patient had a large, but nevertheless fairly well circumscribed, lesion of the cheek and adjacent portion of the alveolar process. It was a lesion which compared favorably with others in which a good result has been obtained. The patient, however, had been treated previously by massive doses of *x*-rays without effect upon the tumor. Although we were not fully aware of it at that time, such treatment renders the tissues far less susceptible to radium, and frequently quite unfits these lesions for the most successful treatment by radium. The patient developed a burn in consequence of the radium treatment, and ultimately did badly.

The following is the case record of one of the cases of advanced cancer of the cheek treated unsuccessfully. It is typical of the lesions forming the majority of those classified throughout the whole of this report as unimproved. He was treated early in our experience with small doses, rather frequently repeated, with practically a negligible benefit.

Case E. O'C. Hosp. No. 21148. Male, 66 years old.

An extensive epithelioma of the right cheek. Seven mild treatments, producing only a small temporary improvement.

Condition on Admission, February 24, 1914.—In the center of the right cheek there is an ulcer 2 inches in diameter. The base and edges of the ulcer are nodular and indurated, and the edges prominent and everted.

Mx: Epidermoid carcinoma.

History.—The ulceration of the cheek was first noticed six months ago. It has gradually grown to the present size.

Treatment.

Feb. 24, 1914: 1 tube; 33 m.c.; 1 mm. lead; to ulcer; 6 hrs.

Mar. 6, 1914; 1 tube; 33 m.c.; 1 mm. lead; to ulcer; 6 hrs.

Mar. 13, 1914: 1 tube; 33 m.c.; 1 mm. lead; to ulcer; 6 hrs.
Mar. 20, 1914: 1 tube; 33 m.c.; 1 mm. lead; to ulcer; 3 hrs.
Mar. 21, 1914: 1 tube; 33 m.c.; 1 mm. lead; to ulcer; 3 hrs.
Apr. 6, 1914: 1 tube; 8.7 m.c.; 1 mm. aluminum; to ulcer; 4 hrs.
Apr. 20, 1914: 1 tube; 8.7 m.c.; 1 mm. aluminum; to ulcer; 4 hrs.

Following the treatment there was some improvement, but finally an extension of the disease. He died Feb. 19, 1915.

Cancer of the Inferior Maxilla

Twelve patients with cancer of the inferior maxilla have been treated. The line of division of these patients and those in which the cancer is primary in the floor of the mouth is not very sharp, but all lesions which appeared to be primary on the alveolar process have been classified as inferior maxillary growths, although in many patients both the lower jaw and the floor of the mouth were involved.

Of these patients one is an adamantinoma of the lower jaw. The result in her case indicates that radium influences adamantinoma very favorably. Five patients have been classed as improved. Three of these are still under treatment and in two the improvement to date has been considerable. The clinical records are as follows:

Case 75 P. F. Hosp. No. 23948. 55 years old.

An extensive epithelioma of the inferior alveolar process and adjacent portions of the floor of the mouth. One external and one internal treatment, with considerable but incomplete retrogression.

Condition on Admission, November 27, 1916.—Between the first molar tooth and the central incisor of the inferior maxillary of the left side is an ulcerated tumor the surface of which is covered with typical neoplastic nodules. The growth involves the adjacent portion of the floor of the mouth and anterior and lateral surfaces of the tongue from the position of the second molar tooth as far forward as a little beyond the frenum to the opposite side of the middle line. In both submaxillary spaces pea-sized nodules of uncertain significance can be palpated. In

the left submental space a definite resistance is produced by the invasion of the floor of the mouth by the tumor. The teeth which still remain in his mouth are in very poor condition.

Mx: Epidermoid carcinoma.

History.—Five months ago a small lump was noticed in the floor of the mouth. It ulcerated and the ulceration increased in size and spread to the alveolar process of the tongue. Several teeth were extracted without benefit. He has been a heavy drinker and smoker; had gonorrhea at twenty-five but denies syphilis. Is unmarried. His teeth fairly free from decay, but show unusual degree of pyorrhea and neglect. His previous health has been good. There is no history of cancer in the family.

Treatment.

Nov. 27, 1916: 12 plaques; 600 m.c.; 2 mm. lead, 3 cm. wood; over left submental and submaxillary space; 15 hrs.

Nov. 28, 1916: 1 tube; 40 m.c.; 1.5 mm. platinum covered with rubber; internally; 2 hrs.

3 tubes; 78 m.c.; 1 mm. platinum and rubber; internally; 2 hrs.

3 tubes; 105 m.c. to 223 m.c.; 1 mm. platinum and rubber; internally; 2 hrs.

Dec. 27, 1916: The ulcer inside the mouth is almost healed. There remains a small diffuse indurated nodule about the size of a bean on the floor of the mouth.

Feb. 19, 1917: 5 tubes; 85 m.c.; 1 mm. rubber-covered platinum; upon nodule in the anterior portion of the floor of the mouth; 2 hrs.

Following this treatment the nodule broke down and an ulcer developed in the floor of the mouth at its site which has since progressively enlarged.

Apr. 29, 1917: 9 plaques; 505 m.c.; 2 mm. lead, 5 cm. distant; to left submaxillary region; 6 hr.

Case A. F. Hosp. No. 24025. Male, 60 years old.

A large epithelioma of the lower jaw and adjacent structures, with an almost complete retrogression to date.

Condition on Admission, December 19, 1916.—Upon the inner surface of the cheek and the adjacent portion of the inferior alveolar process, extending from the anterior pillar of

the fauces to the first molar tooth, is a deeply excavated ulcer, with indurated margins and a hard base, covered with hard, neoplastic nodules. The ulcer measures 1 inch across and is ½ inch deep. There are no glands palpable in the neck or submaxillary space.

History.—Three years ago the two posterior molar teeth were extracted for a painful swelling around them. The wound never healed, but the ulceration which remained gradually increased in size. The ulcer became very painful during the past year. Five months ago another tooth was extracted. This procedure seemed to only hasten the rate of growth of the ulcer. He has used alcohol and tobacco excessively. He has no children. Gonorrhea at 25, and four attacks of pneumonia. No history of cancer in his family.

Treatment.

Dec. 27, 1916: 6 tubes; 150 m.c.; 1 mm. rubber-covered platinum; to ulcer; 3 hrs.

Jan. 17, 1917: A slough has separated over the site of the original ulcer, the whole region of which is now free from induration and covered in the center with what appears to be healthy granulation tissue.

Feb. 7, 1917: Retrogression is practically complete. Later a recurrence of the growth took place with progressive ulceration.

Mar. 27, 1917: Slight increase of the ulceration at the site of the original lesion.

Apr. 11, 1917: 3 tubes; 105 m.c.; 1.5 mm. platinum and rubber; to ulcer; 1½ hrs.

Apr. 12, 1917: 9 plaques; 630 m.c.; 2 mm. lead, 8 cm. distance; to face; 15 hrs.

May 15, 1917: Only small ulcer remains. Its base is clean and it is healing rapidly. Only an insignificant nodule remains in the substance of the cheek external to this ulcer.

Case C. W. Hosp. No. 21355. Female, 62 years old.

Adamantinoma recurrent after operation. A temporary, apparently complete, retrogression following two treatments though the actual presence of disease is at present doubtful.

Condition on Admission, June 8, 1915.—Beneath the right zygoma on the face is a small discoid prominence. At the site of the second and third molar teeth of the upper jaw, inter-

nally, there is a small lump. The patient can only separate the teeth half an inch.

Mx: Adamantinoma.

History.—Since 1907 the patient has been operated upon six times, the last time in May, 1914, for a tumor primary in the body of the lower jaw, in the position of the last right molar tooth.

Treatment.—During October, November and December, 1914, the patient had four radium treatments, with only 10 mgr. for 4 hours, and in June, 1915, a strong treatment externally.

June, 1915: 1 tube; 50 m.c.; 1 mm. silver covered with rubber; internally; 8 hrs.

1 plaque; 50 m.c.; 1 mm. silver covered with rubber; externally; 12 hrs.

Dec. 29, 1915: There is no evidence of any disease present.

Oct. 18, 1916: Indefinite fullness over the external surface of the ramus of the jaw. A small nodule is on the inner surface of the posterior extremity of the superior alveolar process, the size of a hickory nut. It is semi-fluctuating.

Nov. 14, 1916: Again treated.

Mar. 21, 1917: Little evidence of disease though the ramus of the jaw is still thickened and the patient complains of some pain.

Apr. 25, 1917: An indefinite thickening has developed on the inferior maxilla and adjoining portion of the tongue of somewhat uncertain character.

Apr. 25, 1917: 3 tubes; 99 m.c.; 1 mm. platinum, 2 mm. rubber; to thickening on the tongue; 1 hr.

4 plaques; 280 m.c.; 2 mm. lead, 3 cm. distant; to exterior of jaw; 8 hrs.

Case W. D. Hosp. No. 23960. Male, 56 years old.

The improvement in the patient still under treatment is so noteworthy that his clinical record will also be furnished: An advanced epithelioma of the lower jaw. Considerable improvement.

Condition on Admission, December 2, 1916.—Upon the upper and inner surface of the alveolar process of the lower jaw is an ulcerated nodular mass, which involves the adjacent

portion of the floor of the mouth, and is continuous with a second ulcerated, nodular, hard mass, 1 inch in diameter, upon the lateral surface of the tongue, opposite the tonsil. In the right submaxillary region is a hemispherical swelling, about the size of a hen's egg.

Mx: Epidermoid carcinoma.

History.—One month ago he began to feel a pain in the right ear, and a little later in the right side of the neck. At the same time he noticed a tumor in the right side of the neck near the angle of the jaw. Deglutition also became difficult at this time. For the past week there has been a bloody discharge from the mouth. He has lost ten pounds in weight. His previous health has been good. Gonorrhea at 20 years. Formerly smoked excessively. He has four children alive and well. There is no history of cancer in the family.

Treatment.

Dec. 2, 1916: 7 tubes; 168 m.c.; 1 mm. platinum and rubber; to ulcer in mouth; 3 hrs.

12 plaques; 600 m.c.; 2 mm. lead, 3 cm. wood; over gland in neck; 16 hrs.

Jan. 6, 1917: Considerable retrogression has occurred in both the primary tumor and in the tumor in the neck.

Jan. 31, 1917: No sign of radium irritation inside the mouth. The posterior portion of the lesion has retrogressed almost completely. Anteriorly there is still an ulcerated mass present, surrounding the alveolar process, measuring 1 inch in diameter.

Feb. 3, 1917: 10 tubes; 300 m.c.; 1 mm. platinum, 1 mm. rubber; to anterior part of lesion in mouth; 1½ hrs.

Feb. 17, 1917: Glands in the neck are still about the same size, not having increased since last treated.

Feb. 17, 1917: 12 plaques; 800 m.c.; 2 mm. lead, 4 cm. distant; to neck; 13 hrs.

Mar. 20, 1917: The anterior portion of lesion inside the mouth has much improved. Posteriorly the indurations and ulceration have increased in size. Patient complains of some dysphagia and pain.

Apr. 12, 1917: The inferior maxillary branch of the 5th nerve was injected with alcohol. This cause prolonged diminution of the pain in the jaw.

Five patients with epithelioma of the lower jaw must be classed as unimproved. Three of these patients had advanced recurrent growths, and two very advanced primary lesions. As illustrative of these lesions and their course as affected by radium the clinical records of one recurrent case and one advanced primary case are furnished.

Case G. C. Hosp. No. 23960. Male, 60 years old.

A large recurrent epithelioma in neck. Primary growth in the inferior maxilla. Only slight temporary benefit from application directly upon the surface of the skin over the glands in as large doses as this method permits.

Condition on Admission, November, 1915.—The lower jaw has been resected upon the left side. There is a sinus leading into the mouth and opening externally on the skin of the left submaxillary space. The external opening of the sinus is surrounded with an indurated carcinomatous mass of tissue. In the middle of the sternomastoid region of the left side of the neck there is a large nodular swelling 3 x 4 inches in diameter.

Mx: Epidermoid carcinoma.

History.—An ulcer appeared on the inside of the left cheek adjacent to the alveolar border in March, 1915. This was excised soon after it appeared, but quickly recurred. It was again excised in September, and again for another recurrence in October.

Treatment.

Nov., 1915: 2 tubes; 50 m.c.; 3 mm. lead and rubber; in the sinus; 12 hrs.

Jan. 3, 1916: 4 plaques; 330 m.c.; 5 mm. lead and rubber; to glands in neck; 16 hrs.

Feb. 4, 1916: 3 plaques; 480 m.c.; 3 mm. lead and rubber; to 6 areas; 9 hrs.

Died Mar. 1, 1916, after some temporary benefit from treatment.

Case C. McC. 22977. Male, 66 years old.

A very advanced epithelioma of the lower jaw. Two external and one internal treatment, from a limited number of applicators, applied directly, have caused practically no change in the progress of the disease.

Condition on Admission, February 29, 1916.—On the alveolar process of the left side is an ulcer extending from the position of the second molar tooth to the position of the incisor teeth. The ulcer presents a papillary indurated surface, characteristic of epithelioma. The body of the lower jaw is thickened, so that it forms a discoid prominence. Externally and above this prominence there is an ulcer 1¼ inches in diameter, formed of neoplastic tissue which has invaded the whole thickness of the cheek.

Mx: Epidermoid carcinoma.

History.—The patient denies syphilis. He has been a heavy smoker for many years. His teeth have been in a very bad condition for years. Five to six months ago all the teeth on the lower jaw except two on the right side were extracted for what was regarded as an inflammatory ulceration of the gums. The ulceration, however, steadily progressed to the present time.

Treatment.

Mar. 1, 1916: 1 plaque; 75 m.c.; 3 mm. lead covered with rubber; to external ulcer; 14 hrs.

Mar. 6, 1916: 3 tubes; 200 m.c.; 1 mm. platinum and rubber; internally; 12 hrs.

May 10, 1916: 2 plaques; 200 m.c.; 3 mm. lead, ½ inch gauze; externally; 24 hrs.

Local condition has progressed and general condition is very poor.

In addition to these cases of epithelioma of the lower jaw there have been five cases of giant cell epulides of the lower jaw which have undergone a complete retrogression. One of these patients had more than a simple epulis. Her growth was a true sarcoma, with actively growing spindle cells.

The clinical records of these patients are as follows:

Case J. M. Hosp. No. 21378. Female, 26 years old.

A giant cell sarcoma of the lower jaw. Complete retrogression after numerous short treatments.

Condition on Admission, May 30, 1914.—Upon the alveolar process of the lower jaw, on the right side, in the position of the bicuspid and anterior molar teeth, is an ulcerated mass of neoplastic tissue. The external contour of the jaw is distorted

by the growth, producing a fusiform enlargement of the body, palpable from the exterior. Within the submaxillary space is an enlarged lymph node, about ⅜ inch in diameter.

Mx: Giant cell sarcoma with actively growing spindle cells.

History.—The tumor was first noticed three years ago. It was removed by operation in May, 1913. The growth recurred in seven months, and since then has progressively grown to the present size. The patient has always been well previously. No apparent cause for the tumor.

Treatment.

June 2, 1914: 1 tube; 8.7 mgr.; aluminum; to ulcer; 4 hrs.
June 9, 1914: 1 tube; 8.7 mgr.; aluminum; to ulcer; 4 hrs.
June 16, 1914: 1 tube; 8.7 mgr.; aluminum; to ulcer; 4 hrs.
June 26, 1914: 1 tube; emanation; aluminum; 6 hrs.
July 3, 1914: 1 tube; 8.7 mgr.; aluminum; to ulcer; 4 hrs.
July 9, 1914: 1 tube; 8.7 mgr.; aluminum; to ulcer; 5 hrs.
July 14, 1914: 1 tube; emanation; aluminum; 4 hrs.
July 22, 1914: 1 tube; emanation; aluminum; 4 hrs.
July 29, 1914: 1 tube; 8.7 mgr.; aluminum; to ulcer; 5 hrs.
Aug. 5, 1914: 1 tube; 8.7 mgr.; aluminum; to ulcer; 4 hrs.
Aug. 14, 1914: 1 tube; 8.7 mgr.; aluminum; to ulcer; 4 hrs.
Aug. 19, 1914: 1 tube; 8.7 mgr.; aluminum; to ulcer; 5 hrs.
Aug. 26, 1914: 1 tube; 8.7 mgr.; aluminum; to ulcer; 5 hrs.
Sept. 2, 1914: 1 tube; 8.7 mgr.; aluminum; to ulcer; 5 hrs.
Sept. 11, 1914: 1 tube; 8.7 mgr.; aluminum; to ulcer; 4½ hrs.
Sept. 28, 1914: 1 tube; 8.7 mgr.; aluminum; to ulcer; 4 hrs.

July 3, 1916: No evidence of disease is present. The gland in the submaxillary space is unchanged, and the deformity of the jaw bone is still present, but the ulceration is healed and all evidences of the tumor tissue have disappeared.

Feb. 13, 1917: No evidence of disease present.

Case K. J. Hosp. No. 22122. Female, 32 years old.

A giant cell sarcoma of the body of the inferior maxilla. Cured by two unnecessarily severe applications. In consequence the patient's mouth was uncomfortable for one year following the treatment.

Condition on Admission, June 8, 1915.—Covering the site

formerly occupied by the first and second molar teeth of the lower jaw, of the left side, is a lump the size of a walnut. Opposite this externally, over the body of the lower jaw, is a fusiform swelling.

History.—Four years ago a decayed tooth was extracted from the site of the present tumor. Before the tooth was drawn there was an ulcerated condition around it. After it was drawn the ulceration persisted and progressively increased in size to the present time. The patient has had a serious abdominal operation several years ago, and since this her menses have ceased. Her tonsils were removed five years ago. Her father had multiple tumors over the surface of his body.

Treatment.

June 8, 1915: 1 plaque; 75 m.c.; ½ mm. rubber-covered lead; directly; 8 hrs.

June 21, 1915: Tumor smaller, but considerable radium reaction.

June 29, 1915: Reaction largely subsided.

July 6, 1915: 1 plaque; 100 m.c.; 1 mm. rubber-covered lead; 12 hrs.

Aug. 10, 1915: Severe burn within the mouth. Tumor appears to have completely retrogressed, though the deformity of the bone persists.

Dec. 1, 1915: No tumor demonstrable. The burned area on inside of cheek has produced a cicatrix, which limits somewhat opening the mouth, and the patient still complains of much pain inside the mouth.

Case C. A. Hosp. No. 23336. Female, 33 years old.

A typical giant cell sarcomatous epulis. Healed with a single application of radium.

Condition on Admission, June 20, 1916.—On the alveolar process of the lower jaw in the location of the first bicuspid tooth is a small, rounded, red, nodule about the size of a small pea.

History.—The tumor first made its appearance several months ago, and is attributed to injury of the gums inflicted during treatment for pyorrhea. She has undergone an operation, and it was at this time that the tooth in the space occupied by the tumor was extracted.

Treatment.

June 20, 1916: 1 tube; 100 m.c.; 1 mm. platinum covered with rubber; over tumor; 4 hrs.

Aug., 1916: No sign of disease.

Case R. M. Hosp. No. 22230. Female, 13 years old.

A spindle cell sarcoma of the periosteum of the inferior maxilla. Destroyed by two radium treatments.

Condition on Admission, June 20, 1915.—In the position of the last two right molars upon the alveolar process of the right side of the lower jaw is a somewhat elevated firm mass of neoplastic tissue. Externally upon the face there is a fusiform enlargement of the body of the lower jaw opposite the tumor. No glands palpable in the submaxillary space.

Mx: Spindle cell sarcoma of the periosteum. No giant cells are present. The cells are large and not numerous, and the tendency to fibrosis indicates moderate malignancy.

History.—The disease was first noticed last October when a soreness under the jaw attracted her attention to the condition. In June, 1915, an attempt was made to remove the tumor by a local operation, and since the operation it has grown rapidly.

Treatment.

June 20, 1915: 1 tube; 45 m.c.; 0.6 mm. rubber-covered silver; directly; 14 hrs.

June 13, 1915: 1 tube; 100 m.c.; 0.6 mm. rubber-covered silver; 10 hrs.

Following these treatments there was a rapid retrogression which ended in complete clinical retrogression.

Jan. 1, 1916: The patient is free from disease.

Case A. S. Hosp. No. 23512. Female, 7 years old.

Epulis removed by a single application.

Condition on Admission, August 1, 1916.—Between the right canine and first molar teeth, on the alveolar process of the lower jaw is a soft, moderately firm, tumor about ¾ by ½ inch in diameter. It presents the typical appearance of a giant cell epulis.

History.—Three months ago the presence of the nodule was first noticed. It has gradually increased to its present size.

Treatment.

Aug. 23, 1916: 3 tubes; 180 m.c.; 1 mm. platinum covered with rubber; directly around tumor; 2 hrs.

Nov. 29, 1916: Retrogression still complete. A painful lymph node in the right submaxillary space. The bicuspid tooth is decayed, extraction recommended.

One more growth of the lower jaw was treated, a metastatic hypernephroma of the ramus. The clinical record is furnished because the case illustrates well the influence of radium on hypernephroma, which in this case displayed only a slight susceptibility.

Case J. S. Hosp. No. 23852. Male, 49 years old.

A metastatic hypernephroma. Very strong single application.

Condition on Admission, October 28, 1916.—In the external surface of the ramus of the lower jaw of the left side is a hemispherical tumor 2½ inches in diameter at its base. Its consistency is elastic, but there is no fluctuation. The overlying skin is freely movable, but the growth is firmly adherent to the deeper structures. The base of the tumor extends from the lower margin of the jaw to ½ inch from the zygoma and from the groove of the facial artery in front to the posterior border of the ramus behind.

Mx: Metastatic hypernephroma.

History.—Two years ago the patient began to feel a little below par. Six months ago he noticed that he was losing weight. In July, 1916, he accidentally discovered a mass in the right hypochondrium. On July 6, 1916, a hypernephroma of the right kidney was removed. The only special symptom was some increased frequency of micturition three months before the operation. He never noticed blood in the urine. Since the operation he has gained 25 pounds. In Aug., 1916, he first discovered the present tumor. His previous health (before two years ago) has been good. His mother had an epithelioma of her face.

Treatment.

Oct. 28, 1916: 12 plaques; 900 m.c.; 2 mm. lead, 2 cm. wood; over tumor; 18 hrs.

Dec. 7, 1916: No change in size of the tumor. The skin shows slight radium irritation. Patient complains of much pain in the neck.

Cancer of the Floor of the Mouth

Seven patients with cancer, classed as primary, in the floor of the mouth, have been treated. Of these one was treated for recurrence following an operation on the primary growth. This patient is still well after an interval of 18 months. His clinical record is as follows:

Case A. L. Hosp. No. 22240. Male, 58 years old.

Recurrent epithelioma of the floor of the mouth, apparently healed by a single strong application of radium.

Condition on Admission, July 16, 1915.—A small nodule upon the floor of the mouth at the posterior extremity of a scar extending for a short distance backward from the symphysis on the floor of the mouth beneath the lateral border of the tongue.

History.—On June 27, 1915, a small indurated ulcer was excised from the floor of the mouth beneath the tip of the tongue.

Treatment.

July 15, 1915: 1 tube; 50 m.c.; 0.6 cm. rubber-covered silver; to cicatrix in mouth; 12 hrs.

Sept. 1, 1915: Following the treatment there was considerable reaction but at present the burn is healed and there is no indication of the presence of epithelioma.

Four patients with cancer beginning in the floor of the mouth have been greatly improved. All four of these patients are still alive, and in each case the primary lesion has undergone a clinically complete retrogression. All have, however, developed metastases in the lymphatic glands of the neck, which in two patients are so large that it is impossible to cause more than a temporary delay in their course by radium treatment. In the other patient the gland has been removed surgically. At the time of removal it was large enough to have become intimately adherent to the body of the jaw, so that a recurrence is to be feared.

The clinical record of one of the two patients with inoperable metastases in the neck is as follows. The history of this patient is most significant, because it illustrates a complete

control over a primary intra-oral epidermoid carcinoma of long standing and large size, the bar to a complete success apparently being the development of huge metastases in the neck.

In the earlier stages before the lymphatic metastases had developed in the neck these patients would have been cured by a single application of radium.

Case A. M. Hosp. No. 23948. Male, 49 years old.

A complete retrogression of a primary cancer of the floor of the mouth and slight improvement in the secondary glandular tumor of the neck.

Condition on Admission, November 28, 1916.—On the floor of the mouth and anterolateral surface of the tongue, opposite the first right molar and bicuspid teeth, is a small ulcer, with finely papillary surface, ¼ inch in diameter. This ulcer forms the summit of an underlying indurated mass, which has infiltrated the tissues of the floor of the mouth and adjacent surface of the tongue beneath the mucous membrane, between the second right molar and the left canine teeth. Most of the tumor is submucous, and forms a tumor 1 inch in diameter. The right submaxillary and upper cervical lymph nodes are enlarged, forming a large discoid mass beneath the lobe of the ear, and angle of the jaw, 2½ x 2 inches in diameter at its base, and 1 inch in height.

Mx: Epidermoid carcinoma.

History.—His attention was first attracted to his disease two years ago by the appearance of a nodule in the floor of the mouth. The tumor in the neck was first noticed six weeks ago.

Treatment.

Nov. 28, 1916: 7 tubes; 210 m.c.; 1 mm. platinum covered with rubber; to ulcer; 2 hrs.

Nov. 29, 1916: 9 plaques; 540 m.c.; 2 mm. lead, 3 cm. distant; over glands; 16 hrs.

Jan. 17, 1917: There is practically a complete retrogression of the lesion inside the mouth, and the tumor in the neck is smaller and softer. It has broken in the center and about one ounce of pus has exuded.

Apr. 22, 1917: Died without recurrence at the site of the original lesion.

One patient with cancer of the floor of the mouth must be classed unimproved. The failure must be attributed in part to overtreatment of the initial lesion, in part to a rapid and widespread invasion of the cervical lymphatics, and the attempt to deal with them by radium alone.

Unquestionably the cervical lymphatics are involved earlier in cancer of the floor of the mouth than in cancer of the upper jaw or cancer of the cheek. In fact the danger of lymphatic involvement in epidermoid carcinoma of the interior of the mouth is directly proportional to the distance of the original lesion from the first set of regional lymphatics. This is significant because it emphasizes the filtering function performed by the lymphatic glands on cancer cells, and also the possibility of degeneration of cancer cells lodged in the lymphatic vessels between the parent growth and the glands.

Case B. P. Hosp. No. 22275. Male, 51 years old.

Epithelioma of the anterior portion of the floor of the mouth. Intense treatment from one tube, with the production only of an incomplete effect on the growth. Also an incomplete reduction of the glands of the neck from a surface application.

Condition on Admission, July 27, 1915.—Behind the symphysis, in the floor of the mouth, is an indurated nodule ½ inch in diameter. It is ulcerated upon its surface for only a small area, ¼ inch. The tumor is for the most part submucous and involves the alveolar process and adjacent portion of the floor of the mouth to the reflection of the mucosa on the tongue. The surface around the ulcer is nodular and hard. Small pea-like nodules of uncertain significance are in the left submaxillary and submental space.

History. Seventeen months ago he first noticed a small nodule at the location of the present lesion. It caused him varying degrees of discomfort, at times being quite painful. It has gradually grown to the present size, which in his opinion is not much larger than at the first. His Wassermann reaction is positive. His previous health has been good.

Treatment.

July 27, 1915: 1 tube 100 m.c.; 1 mm. rubber-covered lead; to ulcer; 10 hrs.

Aug. 2, 1915: A painful superficial burn on the top of the tongue.

Jan. 2, 1916: several plaques; 250 m.c.; 1 mm. silver and rubber; to submaxillary space; 12 hrs.

1 plaque; 100 m.c.; 1 cm. lead; to new node below mastoid process; 18 hrs.

Jan. 15, 1916; several plaques; 300 m.c.; 3 mm. lead and rubber; to node beneath mastoid; 24 hrs.

1 tube; 75 m.c.; 3 mm. lead and rubber; to ulcer in mouth; 12 hrs.

Within the mouth after each treatment there was a partial retrogression of the tumor, but this was accomplished with increased ulceration, partly inflammatory, around the area treated, so that all in all there was a gradual spread of the ulceration and induration in the mouth. The external treatment was also effective, but only partially so. In consequence of the gradual spread of the process inside the mouth, the patient gradually succumbed to inanition, and died Feb. 25, 1916.

The treatment to the isolated gland in the cubital space was most instructive. It showed a definite effect of the radium through 1 cm. of lead, and a practically complete liquefaction of the mass as a result of 300 m.c. applied in 3 mm. of lead for 24 hours, without the production of more than an erythema and some scaling on the space over the mass.

Cancer of the Soft Palate, Tonsil and Pharynx

Twenty-eight patients with cancer of the soft palate, tonsil and pharynx have been treated, and the results of the treatment of epidermoid carcinoma in this location have been as gratifying as any we have obtained. They have been all the more gratifying because even the early cancers in these locations are excluded in the majority of instances from the field of successful surgical attack.

Cancer of the tonsil, soft palate and pharynx is usually noticed early, because of the comparatively early interference with deglutition. It shows a tendency to early infiltrate the lymphatics, but not so early but that it is frequently discovered before lymphatic extension has taken place. Such was the case in four of the six early cases which we have treated.

Cancer of the tonsil seems to yield to the influence of radium with a rapidity which is so striking that it recalls the susceptibility to radium of other varieties of malignant tumors of the tonsil. This increased susceptibility is not only displayed by the primary growths of the tonsil, but also by their metastatic extensions in the lymphatic glands of the neck. This feature is well illustrated in the case report of the patient selected to represent the improved cases.

On the other hand once a cancer primary in the tonsil invades the tongue, it becomes as difficult to deal with as any epithelioma of the tongue. This observation is certain and clearly demonstrates that the same cancer tissue is influenced in the degree of malignancy which it manifests by nature of the soil in which it grows. In, for instance, the case of the tongue, these modifying factors are doubtless related to the increased blood supply and the constant movement of this organ.

Of the twenty-eight patients with cancer of the tonsil and adjacent structures six have undergone a complete clinical retrogression and are all well, and so far as can be ascertained, are free from disease at the present time. The summaries of their clinical records are as follows:

Case B. J. Hosp. No. 22245. Female, 52 years old.

An alveolar carcinoma of the soft palate. Complete retrogression following two treatments.

Condition on Admission, July 17, 1915.—On the inferior surface of the soft palate at its juncture with the horizontal plate of the right palate bone is an elevated rounded tumor, 1 inch in diameter. Its consistence is firm and elastic. It is not ulcerated.

Mx: Carcinoma, having an alveolar structure.

History.—Six years ago she noticed a small nodule at the site of the present lesion. It remained without much change until three months ago, when it began to grow rapidly to its present size. It causes no pain, and there is only a slight discomfort during swallowing.

Treatment.

July 17, 1915: 1 tube; 100 m.c.; 0.6 mm. silver rubber-covered; to tumor; 6 hrs.

Aug. 26, 1915: 1 tube; 20 m.c.; 0.6 mm. rubber-covered silver; to tumor; 8 hrs.

Following the treatment the tumor gradually retrogressed.

Oct. 28, 1916: Retrogression is still complete. At the site of the old lesion there now remains an indurated cicatrix, depressed somewhat in the center, which has remained unchanged during the past year.

Feb. 13, 1917: Retrogression still complete.

Case D. F. Hosp. No. 23061. Male, 46 years old.

Early epithelioma of the tonsil. Apparently healed.

Condition on Admission, April 7, 1916.—Upon the left tonsil and adjacent portions of the pillars of the fauces is an indurated ulcer, 1 inch in diameter. There are no enlarged lymphatics.

Mx: Epidermoid carcinoma.

History.—The patient first noticed the ulceration of the tonsil about 1 year ago. His general health has always been good.

Treatment.

Apr. 7, 1916: 3 tubes; 250 m.c.; 1½ mm. rubber-covered platinum; to tonsil; 8 hrs.

July 7, 1916: 7 plaques; 700 m.c.; 3 mm. lead; to neck; applied for 6 hours in two places.

Aug. 31, 1916: No evidence of disease inside the mouth or in the neck.

Feb. 3, 1917: Retrogression still complete.

Case W. S. Hosp. No. 23526. Male, 55 years old.

A primary epithelioma of the tonsil and adjacent structures. Two very strong doses to tonsil. Lymphatic glands dissected from the neck and radium left in the wound. At first an apparent complete retrogression, later recurrence in the floor of the mouth.

Condition on Admission, May 10, 1916.—The left tonsil is enlarged, forming a spherical mass 1 inch in diameter, the surface of which is covered with typical small neoplastic nodules. It is fairly firm in consistency and bleeds easily when gently traumatized. The underlying induration has invaded the adjacent portion of the tongue and pillars of the fauces.

Mx: Epidermoid carcinoma.

History.—He first noticed the lesion 4 to 6 weeks ago, when his attention was attracted to it by a disagreeable feeling resembling that of a foreign body in the throat. His previous health has been good. He smokes 2 packets of tobacco a week, about 40 pipefuls a day. He denies syphilis.

Treatment.

May 10, 1916: 2 tubes; 200 m.c.; 1½ mm. platinum and rubber; to tonsil; 4 hrs.

June 15, 1916: No evidence of disease present.

June 23, 1916: 2 tubes; 200 m.c.; 1½ mm. rubber-covered platinum; to tonsil; 2 hrs. This treatment for prophylaxis.

July 12, 1916: The deep cervical glands are enlarged. There is some induration still present in the tongue.

July 25, 1916: A block excision of the cervical and submaxillary glands performed, and at the same time 2 tubes of 1½ mm. of rubber covered platinum imbedded in the submaxillary space and left in place 6 hrs.

Sept. 6, 1916: The nodule on the tongue has increased in size and its center has broken down, forming an ulcer ⅜ of an inch in diameter.

Sept. 6, 1916: 7 tubes; 308 m.c.; 1 mm. platinum and rubber; placed around nodule on the tongue; 6 hrs.

Dec. 6, 1916: There is no ulceration on the tongue. The induration on the lateral surface of the tongue opposite the tonsil seems less. There is no recurrence in the neck.

Jan. 24, 1917: Fresh ulceration has appeared at the site of the original lesion and a sequestrum has formed upon the upper surface of the body of the lower jaw.

The recurrence gradually increased in size till death on April 30, 1917.

Case D. W. Hosp. No. 23517. Male, 74 years old.

Condition on Admission, June 20, 1916.—The left tonsil is enlarged into an irregular globular mass. Its consistency is firm and its surface is covered with minute, hard neoplastic nodules. The tumor appears to be entirely limited to the tonsil. The surrounding tissues being soft. There are no enlarged lymphatics. Slight dysphagia.

Mx: Epithelioma.

History.—The enlargement of the tonsil was first noticed 3 to 4 months ago. He has been an excessive smoker up to the last few years, and since then a moderate smoker.

Treatment.

June 20, 1916: 4 tubes; 340 m.c.; 1½ mm. platinum and rubber; on tonsil; 3 hrs.

Aug. 2, 1916: 10 plaques; 500 m.c.; 3 mm. lead covered with rubber; to neck; 18 hrs.

Oct. 25, 1916: The tumor of the tonsil appears to have completely retrogressed, only a small cicatricial nodule the size of a buckshot remaining.

Dec. 26, 1916: Small enlarged lymphatic has reappeared beneath the middle of the left sternomastoid muscle.

Dec. 26, 1916: 9 plaques; 802 m.c.; 3 mm. lead, 2 cm. wood; to left side of neck; 10 hrs.

Feb. 23, 1917: The enlarged gland removed under local anesthesia.

2 tubes; 50 m.c.; 1 mm. platinum and rubber; within the wound; 1 hr.

May 14, 1917: Free from all evidence of disease.

Case A. G. Hosp. No. 23581. Male, 75 (54) years old.

An early epithelioma of the tonsil. Apparently healed.

Condition on Admission, August 24, 1916.—The left tonsil is the seat of a tumor 1 inch in diameter. The tumor is globular in shape, hard in consistency and covered with small neoplastic nodules. It appears to be entirely limited to the tonsil. Beneath the upper third of the sternomastoid muscle are a few small pea-like nodules.

Mx: Epidermoid carcinoma.

History.—He first noticed the increase in size of the tonsil in December, 1915.

Treatment.

Aug. 24, 1916: 6 tubes; 180 m.c.; 1 mm. rubber-covered silver; to tonsil; 6 hrs.

Oct. 10, 1916: An almost complete disappearance of the tumor, only a small nodule being left in the throat. In the neck there are a few enlarged nodes of uncertain significance.

Oct. 16, 1916: 3 tubes; 90 m.c.; 1 mm. rubber-covered platinum; to ulcer in throat; 2 hrs.

Nov. 10, 1916: 9 plaques; 720 m.c.; 3 mm. lead, 2 cm. wood; to left side of the neck; 18 hrs.

Nov. 17, 1916: 3 tubes; 90 m.c.; 1 mm. rubber-covered platinum; to ulcer in throat; 2½ hours.

Dec. 5, 1916: 12 plaques; 504 m.c.; 3 mm. lead, 2 cm. wood; to right side of the neck; 8 hrs.

Dec. 13, 1916: No evidence of disease present. Throat appears normal.

Case J. Q. Hosp. No. 23699. Male, 51 years old.

Epithelioma of tonsil and adjacent structures. Apparently cured by one treatment.

Condition on Admission, Sept. 14, 1916.—On the anterior pillar of the fauces and adjacent portion of the soft palate is an ulcer ¾ x 1 inch in opposite diameters. It extends from the base of the tongue to the juncture of the hard and soft palate. Its surface and margins are formed of indurated neoplastic nodules. The whole ulcer is flattened and level with the surface of the normal mucous membrane around it. There are no glands palpable in the neck. The appearance of the lesion was typical of epithelioma, but a microscopical diagnosis was not obtained.

History.—He first noticed a soreness in his throat nine months ago. The local discomfort and ulceration gradually increased. He has been a heavy smoker up to five weeks ago. His teeth have been uncared for, but are apparently in a fair condition. His previous health has been good. He denies syphilitic infection.

Treatment.

Sept. 15, 1916; 3 tubes; 126 m.c.; 1 mm. platinum and rubber; to ulcer; 8 hrs.

Jan. 24, 1917: No evidence of disease present.

May 15, 1917: No evidence of disease present.

Fourteen patients with cancer of the tonsil and adjacent structures have been improved. Of these seven are still under treatment. With the exception of two of these fourteen patients all of them had very advanced lesions, involving adjacent portions of all of the structures in the pharynx or associated with large lymphatic metastases.

One of the two exceptions occurred in an old man who lived

at a distance from New York and could not return for subsequent observation; and the other occurred in a native of Panama, who also could not be traced.

The following clinical record illustrates fairly the character of the improvements which can be obtained in advanced cancer of the tonsil.

Case A. DeC. Hosp. No. 24061. Male, 65 years old.

Advanced epithelioma of the tonsil with metastases in the neck, temporarily healed, and considerably delayed in its course.

Condition on Admission, May 12, 1915.—Upon the left tonsil there is an ulcer ¾ of an inch in diameter. Its base and edges are fairly hard and nodular, and involves the base of the tongue by the lower margin. Beneath the upper third of the sternomastoid muscle is an enlarged lymphatic gland, about the size of a walnut.

Mx: Epidermoid epithelioma.

History.—Three years ago the patient noticed an ulcer, with hard base, in the left tonsil. The tonsil was removed nineteen months ago. The lymphatics beneath the upper third of the sternomastoid muscle became enlarged and hard. In the early part of April, 1915, the patient received a course of the mixed toxins by Dr. Coley.

Treatment.

May 12, 1915: 1 tube; 59 m.c.; 1 mm. lead, 2 mm. rubber; on ulcer inside; 12 hrs.

June 20, 1915: Almost no trace of the disease left in the tonsil.

1 tube; 50 m.c.; 1 mm. lead, 2 mm. rubber; to tonsil; 8 hrs.

Oct. 2, 1915: No evidence of the disease is present.

On same date 1 tube; 45 m.c.; 1 mm. lead; to tonsil; 4 hrs.

June 9, 1916: 2 tubes; 100 m.c.; 1½ mm. platinum; to tonsil; 2 hrs.

4 plaques; 400 m.c.; 3 mm. lead, 2 mm. rubber; over the glands in the neck; 8 hrs.

Aug. 5, 1916: On the base of the tongue, opposite the tonsil, there is a very hard, cicatricial-like nodule, the size of a pea. The deep glands beneath the upper third of the sternomastoid

are still enlarged, but no larger than following the treatment one year ago.

Nov. 4, 1916: Condition is practically unchanged. Still difficulty in opening the mouth. He cannot separate the incisors more than half an inch. No lesion within the mouth, except the pea-like nodule noted above, which seems unchanged. He still has considerable pain, referred to the tongue, at times.

Jan. 3, 1917: 12 plaques; 780 m.c.; 3 mm. lead, 3 cm. distant; over enlarged gland on right side of neck; 10 hrs.

On the same date what appears to be a small recurrence on the alveolar margin is noted. A piece of tissue removed from this site showed epidermoid carcinoma.

Jan. 29, 1917: A sudden increase in the ulceration in the tonsillar region has occurred, and on the 29th a hemorrhage with the loss of 5 to 10 oz. of blood. The left external carotid tied and a bunch of glands removed from the left side of the neck, and 2 rubber covered, 1 mm. platinum tubes, containing 38 m.c. each, inserted in the wound.

Mar. 19, 1917: Ulceration in the mouth almost healed. Entirely free from pain. Both sides of neck comfortable. Feels better than in four years.

Case E. W. Hosp. No. 23531. Female, 40 years old.

A very advanced epithelioma of the tonsil and lymph nodes on both sides of the neck, preventing respiration and deglutition. An almost complete clinical relief and reëstablishment of normal deglutition. Also a very marked objective retrogression in the glands of the neck and in the initial lesion. Both the objective and subjective relief in this case was considerable, and up to the present time has lasted nine months.

Condition on Admission, April 22, 1916.—Upon the left side of the neck beneath the upper half of the sternomastoid is a glandular tumor which causes a rounded, hemispherical prominence 3½ inches in diameter at its base. The tonsil is enlarged and infiltrated with an indurated tissue, forming a tumor ulcerated on its surface and invading the adjacent portion of the soft palate and pillars of the fauces. The mouth can be opened only a small amount, and swallowing is difficult. Respiration is accomplished through a tracheotomy tube.

Mx: Epidermoid carcinoma of tonsil.

History.—In August last the patient noticed a small lump beneath the angle of the jaw on the left side of the neck. In Oct., 1915, she noticed that the left tonsil was enlarged. She began to lose weight (20 pounds). In Jan., 1916, the left tonsil was excised. Two weeks ago a tracheotomy was performed. Following the tracheotomy there was a rapid growth of the lumps in the tonsil and neck.

Treatment.

May 16, 1916: 8 plaques; 800 m.c.; 3 mm. rubber-covered lead; over tumor in neck; 12 hrs.

May 22, 1916: 2 tubes; 170 m.c.; 1½ mm. platinum with rubber; to tonsil; 4 hrs.

Following this treatment there has been a progressive diminution of the tumor in the tonsil and in the neck.

By Aug. 5, 1916, there had been a practical disappearance of both, and the tracheotomy tube was removed and deglutition again became possible. At the present time, however, another glandular mass has developed on the right side of the neck.

Aug. 5, 1916: 15 plaques; 900 m.c.; 3 mm. lead, 2 cm. wood; to left side of neck; 6½ hrs.

Oct. 20, 1916: 12 plaques; 960 m.c.; 3 mm. lead, 2 cm. wood; to right side of neck; 12 hrs.

Oct. 25, 1916: The tumor on the right side of the neck is rapidly diminishing in size. Within the mouth at the site of the primary lesion there is an opening in the soft palate which leads into a cavity behind the soft palate, and apparently also through the lateral walls of the pharynx. A thin slough can be seen through this opening at the bottom of the cavity which appears to be ½ inch in diameter. The tissues in the immediate neighborhood are indurated, but altogether the lesion appears unchanged from its condition two months ago. There is no definite evidence that cancer is present in it.

Dec. 18, 1916: A small enlarged lymph node is palpable in the left submaxillary triangle, and another in the anterior parotid region at the site of the original tumor on this side. These were first noticed about three weeks ago, and do not seem to have changed in size since then. There is still present an indolent ulcer in the left tonsillar region. A small specimen removed from this shows epithelioma. The character of this lesion has

not undergone any change in the last few months. The lymphatic tumor on the right side of the neck has completely disappeared, and the skin has almost resumed its normal appearance.

Jan. 4, 1917: 2 tubes; 76 m.c.; 1 mm. rubber-covered platinum; to tonsil; 2 hrs.

Jan. 5, 1917: 12 plaques; 900 m.c.; 3 mm. lead, 2 cm. wood; to left side of neck; 6 hrs.

Following this treatment the patient again improved. The metastases in the neck now form low, rather diffuse nodular swellings. The tissues of the neck feel more diffusely indurated. The response to the radium is far less complete than at first, and associated with this manifest greater resistance of the carcinoma there also seems to be an increase in the connective tissue in the neck.

Feb. 26, 1917: Admitted to the hospital suffering from erysipelas. The condition in the neck is unchanged, but swallowing is becoming increasingly difficult.

Case J. S. Hosp. No. 23725. Male, 63 years old.

Epithelioma of the tonsil and adjacent structures, with glandular metastases in the neck. Apparent complete retrogression of all disease, though the ulceration within the mouth, which is partly due to the radium, has not completely healed as yet.

Condition on Admission, June 28, 1916.—Upon the right anterior pillar of the fauces and adjacent portion of the soft palate, tonsil and superior alveolar process there is an irregular ulcer, rather deeply excavated, but with typically indurated base and borders. The glands beneath the upper portion of the right sternomastoid muscle are enlarged and hard. They form a mass the size of an egg.

History.—Two months ago he noticed a lump in the region of the soft palate on the right side. This ulcerated and increased progressively to the size of the present lesion. Lately he has felt some pain in the throat and experienced some difficulty in swallowing. He has lost considerable weight and strength. His previous health has been good. At the first attempt in treatment the patient swallowed one of the tubes, which was removed by gastrotomy.

Treatment.

Aug. 23, 1916: 4 (?); 120 m.c.; 1 mm. platinum and rubber; to tonsil; 4 hrs.

July 14, 1916: 12 (?); 756 m.c.; 3 mm. lead and rubber; to neck; 12 hrs.

Sept. 19, 1916: 4 (?); 128 m.c.; 1 mm. platinum and rubber; to tonsil; 4 hrs.

Oct. 25, 1916: There is no ulceration in the region of the tonsil, but there is an indurated nodule in the adjacent portion of the tongue ½ x ⅜ inch in diameter. The glandular tumor in the neck has disappeared.

Nov. 15, 1916: Still a small indurated nodule substance of the tongue opposite the tonsil. It seems to be a little less indurated than previously.

Jan. 3, 1917: No glands present in the neck. The radium ulcer is decreasing in size. Edge of tongue is still indurated.

Jan. 24, 1917: The ulceration inside the mouth has improved. No glands are felt in the neck.

Feb. 24, 1917: Fresh ulceration with indurated base involves the right side of the tongue and floor of the mouth opposite the tonsil.

Mar. 28, 1917: 12 tubes; 300 m.c.; 1 mm. rubber-covered platinum; to tongue; ½ hr.

Six patients with cancer of the tonsil and adjacent structures have been classified as unimproved. Two of these patients were recurrent after operation and the other four all had very extensive growths.

As illustrating this group the clinical records of two patients are furnished. The first record is one of the recurrent cases, and illustrates how serious was the blunder which was made by the surgeon who attempted to remove the primary lesion, which apparently was of very small size. The second case record simply illustrates the huge size of some of the lesions which form the statistics, and contribute to list of the unimproved of this report.

Case W. L. Hosp. No. 22783. Male, 69 years old.

A primary epithelioma of the tonsil. Removed by operation. Treated prophylactically at the site of the primary tumor and

over the neck upon the first appearance of lymphatic glands. No return at the site of the primary lesion, but death from progressive advance of the process in the neck.

Condition on Admission, October 23, 1915.—In the position of the right tonsil there is a clean, granulating surface. In the neck no enlarged glands can be felt with certainty.

History.—Five months ago an ulcer appeared upon the right tonsil. The ulcer was cauterized several times, and on October 16th an attempt was made to remove the growth, which was small and strictly limited to the tonsil. Following the operation the patient was referred to this hospital for prophylactic radium treatment.

Treatment.

Oct. 23, 1915: 2 tubes; 200 m.c.; 0.6 mm. rubber-covered silver; to ulcer at site of tonsil; 6 hrs.

Jan. 15, 1916: Enlarged lymphatic glands can be palpated in the neck.

Jan. 15, 1916: 2 plaques; 200 m.c.; 3 mm. lead and rubber; to neck; 24 hrs.

1 tube; 80 m.c.; 0.6 mm. rubber-covered silver; to tonsillar region; 6 hrs.

Feb. 21, 1916: 4 plaques; 400 m.c.; 3 mm. lead; to neck; 22 hrs.

May 21, 1916: 12 plaques; 1200 m.c.; 3 mm. lead; to neck; 6 hrs.

July 3, 1916: 10 plaques; 850 m.c.; 3 mm. lead; to neck; 6 hrs.

Following the first strong application to the neck the skin was rather severely burned. None of these applications produced anything more than a temporary arrest of the growth of the neck tumor. There was a slow increase in size of the tumor in the neck, accompanied with much pain till death, but no return of the tumor in the tonsillar region.

Case J. R. Hosp. No. 23088. Male, 64 years old.

A very large inoperable epithelioma of the tonsil and neck. Very little improvement from five applications of single tubes and plaques to tonsil and glandular swelling in the neck.

Condition on Admission, August 25, 1915.—The right tonsil is replaced by a hard, typical epitheliomatous tumor, which

has invaded the adjacent structures. Externally the cheek over the masseter and buccinator muscles is swollen, forming a large discoid prominence 3 inches in diameter at its base. The jaws are partially ankylosed.

Mx: Epidermoid carcinoma.

History.—His attention was first attracted to this disease last May by an inability to freely open his mouth. Attributing his trouble to his teeth, a number of these were extracted.

Treatment.

Aug. 18, 1915: 1 plaque; 100 m.c.; 1 mm. of rubber-covered silver; to several areas on face; (?) hrs.

1 tube; 75 m.c.; 1 mm. rubber covered silver; to tonsil; (?) hrs.

Sept. 8, 1915: Considerable reduction in size of growth.

Sept. 25, 1915: 1 tube; 40 m.c.; 0.6 mm. rubber-covered silver; to tonsil; 6 hrs.

1 plaque; 40 m.c.; 1 mm. rubber-covered silver; to neck; 6 hrs.

Oct. 9, 1915: 2 tubes; 150 m.c.; 0.6 mm. rubber-covered silver; to tonsil; 12 hrs.

Comparatively little improvement was produced by the treatment, and the patient died on Jan. 4, 1916.

All of the above cases of cancer of the tonsil and pharynx have been treated by attaching single tubes to the lesions by the little hook attached to the ends of the tubes and previously described. The use of these hook tubes is a method of application which, though accurate and successful, is nevertheless a method which we desire to dispense with, because of its traumatizing effect. Lately we have used the molds made of dental composition or lead plates supported by stems held between the teeth by dental composition as holders to retain the tubes against the structures in the posterior portion of the mouth.

Cancer of the Tongue

Forty-eight cancers of the tongue have been treated. Cancer of the tongue is the most difficult form of epidermoid carcinoma to treat, and the most rebellious as regards the production of a complete retrogression. It is very difficult to retain any ap-

plicator satisfactorily upon the tongue. With the majority of the patients whom we have treated the tubes have been fastened to the tongue by means of the hooks. Lately it has been found possible to use the so-called cloth packs, by tying the smallest sized platinum tubes to cotton cloth, and placing such a pack around the tumor, supporting it in place by gauze packing, which also separates, and thus protects, the adjacent mucous membranes from the tongue.

Such packs when they can be used are far preferable to the hook tubes, as they do not wound the tongue. They are easy to apply to the anterior half of the tongue. They may also be applied to the dorsal surface of the back of the tongue, and perhaps as well as any other form of applicator to tumors situated on the lateral border of the middle of the anteroposterior diameter of the tongue directly opposite the tonsil.

Cancer of the tongue is frequent in this location and in our experience it has been the most difficult of all the cancers of the tongue to affect favorably. The explanation depends in part upon the difficulty of surrounding the tumor completely in this location. The only method to adopt is to insist upon the patient holding his tongue out of his mouth during the whole period of application, and placing a nurse on duty beside him to watch the application through, and thus insure the proper retention of the applicator during the whole period of treatment.

All cancers of the tongue display a tendency to early infiltrate the substance of the tongue and the regional lymphatics, a tendency for which the rich lymphatic and vascular supply of the tongue and its constant movement are doubtless responsible. The tendency to early invade the substance of the tongue is especially true of the above described cancers occurring on the lateral border of the tongue opposite the tonsil. At a comparatively early stage in their existence they extend in the direction of the tonsil, filling the normal groove between the tongue and tonsil and rendering the tongue immovable at this place.

Such conditions greatly increase the difficulty of treating these cancers, so difficult to manage under the best conditions. They suggest the advisability of a preliminary cauterization of the growth, for merely the purpose of rendering the region to be treated accessible.

No question is of greater importance in the management of cancer of the tongue than the correct method of dealing with the regional lymphatic nodes; and all that applies to the tongue in this regard also applies to all epidermoid carcinomata of the mouth. It is unsafe to trust to the radium applications to destroy epidermoid cancer in the cervical lymph nodes. In a number of patients whom we have treated external applications have caused a complete and permanent retrogression of such nodes, but this can only be accomplished, at least so far as our experience to date indicates, by a dosage which causes too serious a change in the surrounding normal tissues of the neck. By the technic which we have followed too many of the important tissues of the neck must be brought under the influence of the radium. This conclusion leaves surgical removal as the last resource, and the only question which is open for discussion concerns the time for operation.

In a number of our cases recurrence has followed a primary, so called block dissection, undertaken before lymph nodes became palpable. We, therefore, take the view that it is wiser to give the regional lymphatics a preliminary single and moderately strong dose of radium. Such a treatment may dispose of small deposits in nodes which are not palpable. It will at least seriously damage the proliferative activities of the cancer cells.

Such a preliminary treatment should also be given to enlarged lymph nodes. After an interval of five or six weeks the enlarged nodes should be removed. Instead of performing the routine widespread block dissection only individual tumors should be dealt with, though the entire group of enlarged nodes with the surrounding fat and fascia should be removed in one piece. Such an operation is usually easily performed under novocain anesthesia, and many of the patients who must be dealt with do not well bear a general anesthetic.

Before the wound is closed radium tubes should be placed in the wound in a manner to line the space occupied by the glands. They can thus be placed at the end of the amputated chain of lymphatic vessels coming from the primary growth.

Another advantage in thus delaying the dissection of the neck is the fact that by this time the primary growth is far on toward retrogression, and is no longer in a condition to empty fresh cancer cells into the area operated on, where there

are no longer lymph nodes to encapsulate them. Our experience has satisfied us that the lymph nodes do for a time perform this conservative function efficiently, and too great haste in dealing with them is unnecessary.

Of the 48 cases of cancer of the tongue we have obtained a clinically complete retrogression in only four, and of these four only three are at present free from disease, though all four are still living. Twenty patients are classified as improved, and 24 patients have been very slightly, or not at all improved. These rather disappointing results only emphasize the malignancy of cancer of the tongue.

The four retrogressed cases were all early cases, and of these the two which did the best were the two smallest lesions. By the time carcinoma of the tongue becomes over one centimeter in diameter the possibility of healing it with radium becomes uncertain. The clinical records of the four retrogressed cases are as follows:

Case C. G. Hosp. No. 24057. Male, 59 years old.

Early cancer of the tongue. Apparently cured by a single application.

Condition on Admission, September 29, 1915.—Upon the left side of the upper surface of the anterior third of the tongue there is a small, hard nodule, about 3/8 inch in diameter. The nodule is ulcerated over a very small area in its center.

Mx: Epidermoid carcinoma.

History.—The nodule was first noticed 6 to 7 weeks ago. It was then only slightly smaller and does not seem to have changed in the past two weeks. He contracted syphilis 40 years ago. He is a moderate smoker. His previous health has been good.

Treatment.

Sept. 29, 1915: 1 plaque; 35 m.c.; 1 mm. of rubber covered silver; to ulcer; 8 hrs.

May 5, 1916: No trace of disease present.

Feb. 13, 1917: No trace of disease present.

Case J. L. Hosp. No. 23060. Male, 69 years old.

An advanced but superficial epithelioma of the tongue. A temporary complete clinical retrogression. At present a recurrence of ulceration posterior to the site of the original lesion.

Condition on Admission, April 7, 1916.—Upon the right side of the upper surface of the tongue, opposite the tonsil, there is a large ulcer, 1½ inches in diameter. The base of the ulcer is crossed by a deep crack, and is formed by neoplastic, papillary nodules. Although large, the whole tumor is very superficial. No glands can be felt in the neck.

Mx: Epidermoid carcinoma.

History.—In January, 1916, he first noticed ulceration upon the back of his tongue. The ulcer gradually increased in size, and caused considerable difficulty in swallowing.

Treatment.

April 7, 1916: 3 tubes; 300 m.c.; 1½ mm. platinum, rubber-covered; to ulcer; 8 hrs.

Apr. 26, 1916: The lesion has almost completely disappeared.

July 2, 1916: Still no glands, but for prophylactic reasons the neck is treated.

July 2, 1916: 10 plaques; 1000 m.c.; 2 mm. lead, 2 cm. wood; to neck; 6 hrs.

Sept. 20, 1916: No sign of recurrence, but the patient still has an uncomfortable pain in the back of the tongue, due to persistent radium effect.

Dec. 20, 1916: There is an ulcer covered with a slough in the right pyriform sinus. It is not indurated, and gives the impression of being a late radium effect.

Apr. 4, 1917: The ulceration in the right pyriform sinus has increased in size indicating a true recurrence. The patient is suffering from severe dysphagia and his general condition has seriously deteriorated.

Case J. D. Hosp. No. 23364. Female, 47 years old.

Epithelioma of the tongue, one centimeter in diameter. An apparent complete clinical retrogression.

Condition on Admission, June 26, 1916.—Upon the upper surface of the tongue, near the left border, is a small nodule, one centimeter in diameter. Its consistency is hard. The nodule shows beginning ulceration on its summit, forming a raised tumor, but is almost entirely submucous. There are no enlarged lymphatics in the submaxillary space.

Mx: Epidermoid carcinoma.

History.—The nodule was first noticed on May 31, 1916. It

has been cauterized several times with silver nitrate. She is said to have suffered in the past from hyperthyroidism. There has been no history of any other irritation to the tongue than the habit of drinking very hot tea, coffee and soup. The teeth are in good condition. She had also the habit of biting the side of the tongue when nervous.

Treatment.

June 26, 1916: 4 tubes; 400 m.c.; 1 mm. platinum in rubber; around nodule; 2 hrs.

Following this treatment the surface of the tongue became very painful and raw.

Sept. 27, 1916: The superficial radium inflammation has disappeared and the nodule has completely retrogressed.

Oct. 26, 1916: No trace of disease left.

May 14, 1917: No trace of disease present.

Case M. M. Hosp. No. 23824. Female, 72 years old.

Early, yet well advanced, cancer of the tongue. Partially healed by one treatment.

Condition on Admission.—Upon the left lateral surface of the tongue is a deep ulcer, about ⅜ inch in diameter, surrounded by an extensive, indurated, neoplastic infiltration of the tissues of the tongue for ½ inch in all directions. There is a small, hard gland in the submaxillary space the size of a pea.

Mx: Epidermoid carcinoma.

History.—She first noticed an ulceration on the tongue in Jan., 1916. It has gradually grown to the present size. The patient has had three radium treatments during August elsewhere. Two decayed teeth, which had irritated the tongue, and were opposite the lesion, were extracted three weeks ago. She has had much functional gastric disturbance during the last year. She does not smoke.

Treatment.

Oct. 20, 1916: 7 tubes; 280 m.c.; 1½ mm. platinum covered with rubber; to ulcer; 2 hrs.

Nov. 1, 1916: The induration has diminished 50 per cent. and the ulcer is healing.

The surface of the application is covered with a superficial desquamating epithelium and quite tender.

Jan. 5, 1917: There is no evidence of disease present.

Feb. 7, 1917: Slight increase of the induration at the posterior portion of the lesion.

Feb. 7, 1917: 7 tubes; 294 m.c.; 1 mm. platinum and rubber; to tongue; 1 hr.

Mar. 20, 1917: The ulcer has healed; only a small ulcer remains at the posterior part of the lesion.

Mar. 20, 1917: 16 tubes; 640 m.c.; 1 mm. platinum and rubber; to tongue; ½ hr.

4 tubes; 160 m.c.; 1 mm. platinum and rubber; to floor of mouth; ½ hr.

May 1, 1917: Tongue very painful and ulceration increasing in size.

The improvement in many of the improved cases has been considerable, and we feel certain that with our present experience we can do far better with these same cases in the future. In a number of them death was due to a subsequent involvement of the lymphatic nodes in the neck. Such nodes could have been more successfully dealt with by the combined operative radio-active method above outlined if they had been taken in time.

In other cases patients were allowed to die with only shrunken remnants of the disease in the mouth, remnants which, although composed of relatively little cancer tissue and relatively inactive cancer tissue, nevertheless sapped the patient's strength by binding down the tongue, preventing nutrition and causing pain and loss of sleep. We are now convinced that a local removal of such tissue by the actual cautery would relieve the pain and, if it did not eliminate the remainder of the disease, which it probably would do in the more favorable cases, it would at least make further radium treatment possible. The importance of such a localized removal, easily accomplished under local anesthesia alone, cannot be overestimated.

The following clinical records are striking illustrations of the improvements which can be accomplished by radium in advanced cancer of the tongue.

Case D. O'C. Hosp. No. 21593. Male, 53 years old.

Fairly well advanced epithelioma of the tongue. Eight fre-

quently repeated mild radium treatments, followed by superficial healing, but later extension of the disease into the substance of the tongue.

Condition on Admission, August 28, 1914.—Upon the anterior portion of the upper surface of the tongue is a slightly raised indurated ulcer about the size of a silver quarter. Its base and edges are hard, but there is very little deep infiltration of the tongue. The whole lesion is quite superficial. No enlarged glands can be felt in the submaxillary space.

History.—The patient contracted syphilis at 28 years, and received treatment for the following two years. He has been a heavy drinker and smoker. Opposite the ulcer on the tongue are several decayed, partially destroyed teeth. The present growth was first noticed last May as a small ulcerated nodule which has gradually developed into the present lesion.

Treatment.

Between Aug. 28, 1914, and Dec. 7, 1914, he received eight radium treatments with at first 16 and later 25 m.c., for periods of five hours at a time. This treatment produced a superficial healing, which at one time was quite marked, but was followed later by deep infiltration of the substance of the tongue. Finally the ulceration on the tongue reappeared, and increased in size, the tongue became immovable, and treatment was discontinued. He died a few months later.

Case C. N. Hosp. No. 23153. Male, 57 years old.

Primary epithelioma of small size upon the upper surface of the tongue. Complete healing by centrally placed single tubes and strong dosage. Subsequent recurrence on the opposite side of the tongue and in the glands of the opposite side of the neck, both of which resisted treatment.

Condition on Admission, August 5, 1915.—Upon the left side of the upper surface of the tongue, opposite the base of the tonsil, there is a slightly raised, flattened ulcer, about 1 inch in diameter. The base and edges of the ulcer are indurated. The surface is flat and covered with characteristic neoplastic nodules and irregularities. A very small, pea-sized node can be felt in the left submaxillary space.

Mx: Epidermoid epithelioma.

History.—The ulceration on the tongue was first noticed on

the 8th of May, 1915. There has been no pain in connection with it. It has gradually increased to the present size. He denies syphilis. His teeth have been all removed 20 years ago and for the past 19 years he has worn a poorly fitting plate which has irritated the mouth. He has been a heavy smoker.

Treatment.

Aug. 6, 1915: 1 tube; 50 m.c.; 0.6 mm. silver covered with rubber; to ulcer; 8 hrs.

Sept. 22, 1915: 1 tube; 75 m.c.; 0.6 mm. silver covered with rubber; to ulcer; 6 hrs.

Nov. 11, 1915: Whole lesion has disappeared, except one small nodule.

Dec. 1, 1915: 1 tube; 75 m.c.; 0.6 mm. silver covered with rubber; to nodule; 4 hrs.

Jan. 18, 1916: Following last treatment a rather severe radium inflammation developed, which has now about disappeared.

Mar. 18, 1917: No induration and no glands in the submaxillary space can be felt.

May 3, 1916: A small, deep, cervical lymph node can be felt beneath the upper portion of the right sternomastoid muscle.

May 3, 1916: several plaques; 500 m.c.; 3 mm. lead and 2 mm. rubber; to left side of neck; 8 hrs.

several plaques; 600 m.c.; 3 mm. lead and 2 mm. rubber; to right side of neck; 8 hrs.

July 12, 1916: 12 plaques; 600 m.c.; 3 mm. lead and 2 cm. wood; to right side of neck; 18 hrs.

The node beneath the upper one-third of the right sternomastoid forms a lump of considerable size, at least 1½ inches in diameter.

Aug. 16, 1916: A small ulcer with typically indurated base and edge exists on the upper surface of the tongue, immediately contiguous to the right tonsil.

Aug. 16, 1916: 1 tube; 20 m.c.; 1 mm. platinum and rubber; to ulcer; 5 hrs.

Oct. 3, 1916: 12 plaques; 936 m.c.; 3 mm. lead, 2 cm. wood; to right side of neck; 12 hrs.

Oct. 18, 1916: 3 tubes; 117 m.c.; 1 mm. platinum and rubber; to ulcer on tongue; 2 hrs.

Nov. 1, 1916: The ulcer on the tongue has softened con-

siderably and the tumor in the neck has reduced to half its size before the treatment. Following this treatment there was a gradual increase in size of the ulcer on the right side of the tongue and a gradual deterioration of his general health, precluding further treatment.

Jan. 11, 1917: Died with hemorrhage from the tongue.

Case J. C. Hosp. No. 22343. Male, 67 years old.

A very extensive cancer of the tongue and floor of the mouth, brought to a relatively complete retrogression by two treatments. Life prolonged perhaps one year and the patient's mouth rendered comfortable for this period.

Condition on Admission, August 16, 1915.—The whole of the right side of the anterior three-fourths of the tongue is the seat of a growth, which fills the alveolar lingual space, and causes a thickening of the tongue to twice its normal size. The growth while quite voluminous, has a papillary surface. The mobility is only slightly restricted. He has been in considerable pain, referred to the ears, during the last two months, and deglutition has been difficult during the same length of time. No glands can be felt in the submaxillary space. He has lost no weight.

Mx: Papillary epidermoid carcinoma.

History.—Four years ago he noticed a tickling sensation on the tongue. This increased during the next six months, when he noticed a nodule twice the size of a pea upon the side of the tongue. This gradually increased in size. Three months ago it was 1 inch in diameter. He denies syphilis. He is not a drinker. He has smoked a pipe for the past ten years. The teeth on the lower jaw have been in a very bad condition for the past twenty years. An aunt died of cancer of the breast.

Treatment.

Aug. 17, 1915: 2 tubes; 100 m.c.; 0.6 mm. silver covered with rubber; to tongue; 12 hrs.

Sept. 14, 1915: 2 tubes; 35 m.c.; 0.6 mm. silver covered with rubber; to tongue; 18 hrs.

Sept. 21, 1915: A very considerable improvement, a marked diminution in the size of the tumor. The mass has practically disappeared, leaving a flattened, indurated surface on the tongue. The thickness of the tongue has decreased.

Oct. 11, 1915: 3 tubes; 150 m.c.; 0.6 mm. silver covered with rubber; to tongue; 6 hrs.

Nov. 22, 1915: 4 tubes; 200 m.c.; 0.6 mm. silver covered with rubber; to posterior portion of tongue; 6 hrs.

Dec. 8, 1915: 1 plaque; 100 m.c.; 1 mm. silver covered with rubber; to upper surface of tongue; 4 hrs.

Jan. 10, 1916: 2 tubes; 50 m.c.; 3 mm. lead covered with rubber; to tongue; 12 hrs.

Feb. 9, 1916: The tongue is becoming diffusely indurated, and the submaxillary lymphatics are becoming enlarged.

Feb. 9, 1916: 2 tubes; 355 m.c.; 1½ mm. platinum covered with rubber; to alveolar lingual groove; 8 hrs.

Apr. 4, 1916: 5 plaques; 580 m.c.; 3 mm. lead covered with rubber; to submaxillary region; 8 hrs.

Apr. 25, 1916: There is a marked reduction in the size of the lymphatic glands.

Apr. 25, 1916: 6 plaques; 600 m.c.; 3 mm. lead covered with rubber; to submaxillary region; 6 hrs.

Following the last treatment the diffuse swelling and immobility of the tongue became more marked and the deglutition increasingly difficult.

Feb. 20, 1917: Died. Son stated that during the last six months he had been comfortable and not in pain, and that all who had followed his condition were agreed that the treatment had rendered the course of his disease more comfortable.

Case M. M. Hosp. No. 22687. Female, 52 years old.

A very extensive, but superficial, cancer of the tongue, involving the whole of one side of the tongue. Healed without recurrence inside the mouth to the day of her death, one year later. Death from lymphatic metastases, which were practically uninfluenced by massive doses.

Condition on Admission, December 9, 1915.—The whole left lateral surface of the tongue from the pillars of the fauces to the tip and the adjacent portion of the floor of the mouth is ulcerated. The surface of the ulcer and its margins are formed of papillary-like nodules and are indurated. There is very little deep extension of this induration into the submucous tissue. The lymph nodes in the left submaxillary space are enlarged.

Mx: Epidermoid carcinoma.

History.—She first noticed ulceration in the mouth in last April (1915). This appeared opposite a poorly fitting bridge, which irritated the side of the tongue.

Treatment.

Dec. 9, 1915: 3 tubes; 100 m.c.; 0.6 mm. silver covered with rubber; to tongue; 2 hrs.

Dec. 19, 1915: 4 plaques; 300 m.c.; 1 cm. lead, ½ inch gauze; to neck; 8 hrs.

Jan. 19, 1916: Ulceration inside the mouth is rapidly healing, and there is no residual induration. The patient's whole condition transformed by the cessation of the foul discharge from the mouth.

Jan. 19, 1916: 2 tubes; 200 m.c.; 3 mm. lead covered with rubber; to tongue; 12 hrs.

June 12, 1916: 5 plaques; 575 m.c.; 3 mm. lead covered with rubber; to both sides of neck; 6 hrs.

Lymphatic glands beneath the sternomastoid on both sides of the neck are enlarged, but no trace of disease inside the mouth.

July 14, 1916: 12 plaques; 600 m.c.; 3 mm. lead covered with rubber; each side of neck; 12 hrs.

Sept. 30, 1916: The tumor on the right side of the neck is cystic and about the size of a small orange. On the left side of the neck there is a group of hard lymphatic nodes, forming a mass the size of three or four grapes.

Sept. 30, 1916: 12 plaques; 540 m.c.; 3 mm. lead; 2 cm. wood; to right side of neck; 18 hrs.

The tumor in the right side of neck incised and 2 oz. of clear fluid evacuated. The walls of this cavity are thick and dense and formed apparently of fibrous tissue alone.

Sept. 30, 1916: 12 plaques; 828 m.c.; 3 mm. lead and rubber, 2 cm. wood; to left side of neck; 18 hrs.

Oct. 25, 1916: 12 plaques; 744 m.c.; 3 mm. lead, 2 cm. wood; to right side of neck; 18 hrs.

Dec. 5, 1916: Died from the metastases in the neck. No recurrence of the disease on the tongue.

All of the twenty-four unimproved patients with cancer of the tongue had advanced or recurrent lesions.

The following case records are representative of some of the conditions treated:

Case E. G. Hosp. No. 22692. Male, 66 years old.

Very extensive epithelioma of the tongue. Treatment alone for psychic effect. Insignificant temporary improvement.

Condition on Admission, December 13, 1915.—The whole upper surface of the tongue, with exception of one-third of the right half, is covered with a ragged indurated ulcer. There are small, hard, enlarged lymphatics in the submaxillary space.

History.—An ulceration first appeared on the upper surface of the tongue near its tip last January (1915). He denies syphilis. He has received two neosalvarsan injections. He has been a heavy smoker, and has had some leukoplakia upon the tongue for years.

Treatment.

Dec. 13, 1915: several plaques; 350 m.c.; 1 mm. silver covered with rubber; to neck; right side 8 hrs., left 6 hrs.

Dec. 17, 1915: 2 tubes; 200 m.c.; 0.6 mm. silver covered with rubber; to tongue; 3 hrs.

The treatment produced a slight temporary improvement, and he died on Jan. 30, 1916.

Case W. S. Hosp. No. 23127. Male, 65 years old.

Large inoperable cancer of the tongue. Two strong treatments followed by no appreciable effect on the course of the disease.

Condition on Admission, April 26, 1916.—Upon the right border and lateral surface of the tongue, about the middle of the anteroposterior diameter of the tongue is an ulcer 1 inch in diameter. The ulcer is excavated. Its base and borders are hard. Undermining it, and surrounding it is a considerable thickness of indurated tissue which deeply involves the substance of the tongue. No glands were at first felt in the neck.

History.—Thirty years ago he had some growth on the lower lip, which was removed by a plaster. There has been no recurrence. Two months ago he first noticed an ulceration upon his tongue.

Treatment.

Apr. 26, 1916: several tubes; 330 m.c.; 1½ mm. platinum in rubber; to ulcer; 4 hrs.

May 31, 1916: The ulcer has diminished in size and is healing over, but a diffuse infiltration is spreading through the

tongue, which is rendering the tongue immovable, and gradually making talking and swallowing increasingly difficult. The submaxillary lymphatics have become palpable.

June 14, 1916: 5 tubes; 325 m.c.; 1½ mm. platinum in rubber; to ulcer; 2 hrs.

Following this last treatment there was fresh ulceration, which a little later partially healed over. There was, however, a continuation of the diffuse infiltration of the tongue, and increase of dysphagia, and death on Oct. 3, 1916.

Case M. L. Hosp. No. 23869. Male, 46 years old.

Marked temporary improvement in an advanced cancer of the tongue.

Condition on Admission, November 4, 1916.—On the upper surface of the left half of the tongue there is an elevated, flattened ulcer, 1½ x 1 inch in diameter. Its base and edges are hard and nodular. The surrounding tongue tissue is soft, with the exception of an isolated nodule, ½ inch long and 3/16 inch wide, upon the surface of the tongue to the inner side of the tumor. This nodule is separated by apparently healthy tongue tissue from the main lesion. The substance of the tongue appears to be infiltrated beneath the ulcer to a depth of ¼ inch. In the left submaxillary space there is a gland the size of a hickory nut.

Mx: Epidermoid carcinoma.

History.—He first noticed a nodule at the location of this lesion 12 months ago, at the site of an injury to the tongue produced three months previous by a fish bone. The nodule has gradually grown to its present size. He has had no treatment. He denies syphilis, is a heavy smoker, and many of his teeth are in a very poor condition. The second and third molars of the left side of the lower jaw are absent. The first molar is decayed and tender.

Treatment.

Nov. 4, 1916: 12 tubes; 360 m.c.; 1 mm. platinum; to tongue; 2 hrs.

Dec. 26, 1916: The lesion on the tongue shows a marked retrogression, probably one-third its original size. The gland in the neck shows no change. The nodule to the inner side of the main mass has disappeared.

Dec. 26, 1916: 9 plaques; 540 m.c.; 2 mm. lead, 3 cm. distant; over gland in neck; 15 hrs.

Feb. 15, 1917: For the past four to five weeks there has been a progressive increase in the infiltration beneath the base of the lesion, and in the ulceration on its surface. The indurated tissue now forms a globular mass 1½ inches in thickness, having crossed the middle line, and involving the other side of the tongue. On the lateral surface of the tongue there are two ulcers, both ½ inch in diameter. The submaxillary gland is about the same size.

Feb. 26, 1917: 18 tubes; 720 m.c.; 1 mm. platinum and rubber; to tongue; ½ hr.

Following this treatment, which practically covered the whole tongue, there was a most satisfactory retrogression of the whole mass. The base of the ulcer became clean and the thickness of the affected side of the tongue reduced to that of the opposite side. The glands of the neck remained about the same size.

Mar. 31, 1917: The contents of the left submaxillary space removed and 3 tubes each containing 25 m.c. placed in the wound for 2 hrs. Following this operation there ensued a continued retrogression of the mass on the floor of the mouth of the left side, but a slow development of a gland in the right submaxillary space.

Case G. M. Hosp. No. 23304. Male, (?) years old.

A very large inoperable cancer of the tongue. Practically unbenefited, possibly made worse, by five heavy treatments.

Condition on Admission, June 10, 1916.—The left half of the tongue has been removed. The surface of the defect left by this operation is covered by indurated nodules, and the underlying tissue is infiltrated with a dense, hard, neoplastic tissue. The ulceration has also involved the left half of the soft palate. In the submaxillary region there is a scar left by the resection of the contents of this space, and in the center of this scar is a fistulous opening.

History.—In Jan., 1916, he first noticed ulceration on the left border of his tongue. It gradually increased in size. In Mar., 1916, he noticed that the glands in the neck were enlarged, and on Mar. 19 they were removed. On Apr. 25, 1916, the left half of the tongue was excised. A recurrence soon

took place, which has progressively grown to the present lesion.

Treatment.

June 10, 1916: 3 plaques; 300 m.c.; 3 mm. lead, 2 cm. wood; to neck over sinus; 8 hrs.

June 13, 1916: 5 tubes; 500 m.c.; 1½ mm. platinum covered with rubber; to ulcer in mouth; 2 hrs.

July 19, 1916: 12 plaques; 840 m.c.; 3 mm. lead, 2 cm. wood; to neck; 16 hrs.

Aug. 9, 1916: Skin of neck reddened; no essential improvement inside of mouth.

Sept. 18, 1916: 3 tubes; 114 m.c.; 1 mm. platinum covered with rubber; in the mouth; 4 hrs.

Oct. 21, 1916: The external sinus has enlarged to an ulcer with hard, neoplastic walls. Inside the mouth the condition is about the same. There is a large ulcer with necrotic walls, but comparatively little induration around it.

Oct. 21, 1916: 12 plaques; 816 m.c.; 3 mm. lead, 2 cm. wood; to neck; 12 hrs.

No real improvement followed the last treatment and he died on Nov. 15, 1916.

Cancer of the Larynx

We have treated twenty-seven patients with cancer of the larynx. Of these a clinically complete retrogression was obtained in four, but three of these patients died later from a recurrence. One is still alive and is now being treated for a small recurrence. The recurrence is yielding, and he is at present in a promising condition.

The summary of the clinical records of these cases is as follows:

Case M. D. Hosp. No. 22084. Male, 48 years old.

Recurrent cancer of the larynx. Complete clinical retrogression produced by internal treatment. Death from recurrence.

Condition on Admission, May 18, 1915.—On the posterior surface of the epiglottis is a broad ulcerated area. It is impossible to see the interior of the larynx well but the left vocal cord can be seen and appears normal.

Mx: Typical epidermoid carcinoma.

History.—His attention was first called to his disease in

Aug., 1914, by the development of aphonia. An examination revealed the tumor, and a hemilaryngectomy was performed Oct. 25, 1914.

Treatment.

May 31, 1915: An unrecorded intralaryngeal treatment.

June 20, 1915: 1 tube; 70 m.c.; 0.6 mm. silver; inside the larynx; 8 hrs.

July 2, 1915: 3 tubes; 150 m.c.; 0.6 mm. silver; inside the larynx; 6 hrs.

Oct. 16, 1916: The patient has passed through a severe radium reaction, but is now in excellent condition. He has gained 20 pounds and looks well. His larynx is comfortable and appears free from disease.

Nov. 22, 1915: A small, elevated, suspicious-looking nodule has developed at the site of the old lesion.

Nov. 22, 1915: 1 tube; 50 m.c.; 0.6 mm. silver; inside the larynx, 4 hrs.

Following the last treatment there was a recurrence of the ulceration and sloughing inside the larynx, and death from inhalation pneumonia.

Case A. B. Hosp. No. 23718. Male, 60 years old.

Primary epithelioma of the epiglottis. Complete local retrogression of the primary growth produced by internal treatment. Death later from secondary involvement of the cervical lymphatic glands, which were only incompletely affected by external treatment.

Condition on Admission, December 30, 1915.—Upon the anterior and posterior surfaces of the epiglottis is a large papillomatous mass, which also extends into the right pyriform sinus. Phonation is normal. There is some difficulty in swallowing. The patient is well nourished and very stout.

Mx: Epidermoid carcinoma.

History.—Eight months ago his attention was first attracted to the disease by some difficulty in swallowing.

Treatment.

Dec. 30, 1915: 1 tube; 100 m.c.; 0.6 mm. silver covered with rubber; on epiglottis inside larynx; 3½ hrs.

Feb. 20, 1916: 1 tube; 100 m.c.; 1½ mm. platinum covered with rubber; on right side of epiglottis; 7 hrs.

Following this treatment there was a rapid disappearance of the growth on the epiglottis, so that by the end of March no growth at all remained in the larynx or epiglottis. The glottis was somewhat deformed and a little more rigid than normally, so that a little difficulty in swallowing was noticed. A small gland was palpable on the left side of the neck.

Apr. 20, 1916: 1 plaque; 400 m.c.; 3 mm. lead, 2 mm. rubber; to neck; 8 hrs.

June 30, 1916: The gland in the neck is reduced in size and was excised.

Following the operation there sprung up a rapid diffuse swelling of the neck with a definite nodule behind the position of the gland which was removed.

June 30, 1916: 12 plaques; 600 m.c.; 3 mm. lead, 1 cm. gauze; over the glandular swelling; 18 hrs.

Following this treatment the tumor softened and was finally incised on Sept. 8, 1916. A large quantity of fluid and broken-down tissue was evacuated. This afforded him little relief.

Deglutition became more and more difficult, though an examination of the larynx revealed no trace of disease.

Sept. 23, 1916: Died.

Case D. M. Hosp. No. 22964. Male, 54 years old.

Cancer of the vocal cords. Complete disappearance of all evidences of the disease following a single massive dose applied externally to the neck. Later death from progressive asthenia without objective signs of recurrence in the larynx or esophagus.

Condition on Admission, March 9, 1916.—The posterior half of the left vocal cord is ulcerated. The surface of the ulcer appears eaten out into grooves, between which there are minute nodular elevations. There are no large masses in the larynx, and the growth is a very early one and seems limited to the vocal cords.

Mx: Epithelioma.

History.—Aphonia developed two years ago. He was treated by sprays for 16 months. Thirteen months ago the aphonia became suddenly worse. His larynx was then examined and a piece of tissue removed for microscopic section. The section showed epithelioma.

Treatment.

Mar. 9, 1916: 4 plaques; 700 m.c.; 3 mm. lead, ½ inch of gauze; to neck; 18 hrs.

Mar. 14, 1916: Voice decidedly better.

Apr. 7, 1916: The patient has developed a superficial burn of the skin at the place where the radium was applied.

July 5, 1916: 1 tube; 80 m.c.; 1 mm. platinum and rubber; inside the larynx; 2 hrs.

Aug. 9, 1916: No sign of disease within the larynx. The superficial burn on the skin in front of the neck is still unhealed.

Later, without apparent development of fresh ulceration in the larynx, deglutition became increasingly more difficult, without obstruction in the esophagus, and the patient died in a most emaciated condition on Aug. 26, 1916.

Case H. E. Hosp. No. 23212. Male, (?) years old.

Moderately advanced epithelioma of the epiglottis, greatly improved by local applications.

Condition on Admission, May 17, 1916.—Covering the surface of the epiglottis is a nodular papillary mass. The upper border and anterior surface of the right side are chiefly involved. The interior of the larynx appears to be clean.

Mx: Epidermoid carcinoma.

History.—The patient first became aware of his disease three years ago, experiencing at that time some discomfort in the throat. He then developed a cough. After five months the cough became accompanied with expectoration.

Treatment.

May 17, 1916: 2 tubes; 300 m.c.; 1½ mm. of rubber-covered platinum; inside of larynx; 4 hrs.

July 2, 1916: 10 plaques; 900 m.c.; 3 mm. lead; to right side of neck; 6 hrs.

10 plaques; 900 m.c.; 3 mm. lead; to left side of neck; 6 hrs.

July 15, 1916: 2 tubes; 54 m.c.; 1 mm. of rubber-covered platinum; inside of larynx; 5 hrs.

Aug. 10, 1916: 2 tubes; 40 m.c.; 1 mm. of rubber-covered platinum; to right side of larynx; 8 hrs.

Sept. 30, 1916: 1 tube; 33 m.c.; 1 mm. rubber-covered platinum; inside of larynx; 6 hrs.

Sept. 30, 1916: The papillary mass upon the epiglottis has disappeared. The epiglottis is much thickened and reddened. The disease has spread to inside the cavity of the larynx, causing a nodular ulceration, chiefly limited to the posterior surface of the epiglottis.

Oct. 16, 1916: 2 tubes; 60 m.c.; 1 mm. of rubber-covered platinum; inside larynx; 2 hrs.

Nov. 18, 1916: 4 tubes; 96 m.c.; 1 mm. of rubber-covered platinum inside larynx; 2 hrs.

Dec. 18, 1916: 4 tubes; 100 m.c.; 1 mm. of rubber-covered platinum; inside larynx; 2 hrs.

Jan. 20, 1917: 9 plaques; 630 m.c.; 3 mm. lead; to right side of neck; 10 hrs.

The patient has pain in the larynx and difficulty in speaking. There is a small gland palpable behind the ramus of the jaw on the right side.

Mar. 3, 1917: The gland in the neck is reduced to a small nodule not larger than a small marble. The evidence of disease inside the larynx has almost completely disappeared.

Seven other cases of cancer of the larynx have been improved. The following case record is illustrative of the character of some of these improvements:

Case J. W. Hosp. No. 22763. Male, 57 years old.

Advanced cancer of the larynx. Marked temporary improvement lasting four months, following two external treatments.

Condition on Admission, January 18, 1916.—Upon the inner surface of the left lateral wall of the larynx and the posterior surface of the epiglottis is an elevated ulcer, about 1 inch by ½ inch in diameter. The opposite lateral wall is thickened, and both cords are obscured.

History.—He first developed laryngeal symptoms in May, 1915. These symptoms were coughing and a bloody expectoration. About one month ago he began to have difficulty in deglutition, and a laryngeal voice developed. He can now only speak in a whisper and swallow liquids with the greatest difficulty.

Treatment.

Jan. 8, 1916: several plaques; 200 m.c.; 1 mm. of rubber covered silver; to neck; 12 hrs.

Feb. 5, 1916: several plaques; 350 m.c.; 3 mm. lead covered with rubber; to right side of neck; 14 hrs.

several plaques; 350 m.c.; 3 mm. lead covered with rubber; to left side of neck; 14 hrs.

Following this treatment there was a marked improvement. The patient's voice returned. He was able to speak and eat without difficulty, and his respiration became easy.

Feb. 19, 1916: 4 plaques; 600 m.c.; 3 mm. lead covered with rubber; to both sides of neck; 12 hrs.

The improvement continued until the middle of May. Within the larynx there was a marked diminution in the size of the tumor mass. The vocal cords became visible.

In the middle of May the growth acquired a new activity, the larynx filling up and necessitating a tracheotomy. He died three weeks after the tracheotomy.

The improvement which this patient made enabled him to resume his practice (he was a physician) for four months; and his own words addressed to me shortly before his tracheotomy was performed were: "If you have done nothing more, Doctor, than give me the relief which I have already experienced, you have accomplished a great deal."

Sixteen patients, all, with one exception, very advanced cases of cancer of the larynx, must be classed as very slightly or not at all improved. The single exception was an old man, who died of inhalation pneumonia following the development of a slough upon the ulcer within the larynx, seven weeks after treatment.

The following case record represents these cases:

Case A. K. Hosp. No. 22469. Male, 52 years old.

Advanced epithelioma of the pyriform sinus of the larynx. Two treatments, one internal and the other external, from single applicators, with a very temporary improvement.

Condition on Admission, September 28, 1915.—The pharyngeal wall of more especially the right side is the seat of an extensive neoplastic ulceration which extends to the bottom of the right pyriform sinus. No lymphatics palpated.

Mx: Typical epidermoid carcinoma.

History.—His attention was first attracted to his disease last November by the development of aphonia and the symptoms of

an acute laryngitis. His previous health has always been good. He denies syphilis. He is not a heavy drinker but is a heavy smoker. For his present trouble he has received mercury and salvarsan, though his Wassermann reaction is negative.

Treatment.

Sept. 28, 1915: 2 tubes; 80 m.c.; 0.6 mm. silver covered with rubber; internally; 8 hrs.

2 plaques; 150 m.c.; 1 mm. silver covered with rubber; externally to the neck; 12 hrs.

Oct. 1, 1915: The size of the lesion has diminished 50 per cent.

Dec. 18, 1915: He has been drinking heavily and has been treated by some outside physician by sprays and can now hardly swallow. His tumor has increased in size and the whole condition is hopeless.

There can be no question that these results do not represent what should be accomplished in the treatment of cancer of the larynx by radium. It is a form of cancer which is usually discovered early enough to yield to radium, as judged by the effects of radium on similar growths situated elsewhere. The great difficulty concerns the accuracy of application.

The majority of our cases have been treated by the insertion of single tubes within the larynx, retaining them in place by the little barbed hooks. A few of the earlier cases have been treated by the insertion of single tubes on the end of long wires which are held between the teeth. A few cases have also been treated entirely by external application.

Since we have had the three millimeter platinum tubes, the direct application of radium to cancer of the larynx has been greatly simplified. In intrinsic cancer of the larynx several of these tubes, enclosed end to end in a small-sized rubber tube, may be passed into the larynx. If the position of the upper tube is marked by a ligature, the whole series can be withdrawn until this tube is just above the carcinomatous area, which will now be in contact with one or more radium tubes. Such a method is far more exact than when single tubes, which are difficult to place at the exact desired level, are inserted into the larynx.

The greatest care should be exercised in attempting to treat

a patient with carcinoma of the larynx without a preliminary tracheotomy. If the case is early it is possible to do so without danger, though even in such a patient the dose should be very carefully adjusted. If, however, the lesion surrounds a large part of the laryngeal cavity there will be an additional constriction of the laryngeal cavity produced by the swelling and edema following the treatment. A preliminary tracheotomy need not be done in the early cases. We have treated a number without it, and have never had an unfortunate accident from failure to perform a preliminary tracheotomy.

Before we appreciated the necessity of a preliminary tracheotomy in patients having disease of a sufficient grade, we nearly lost one patient from edema of the larynx following treatment, and would have done so if it had not been for the prompt action of the resident surgeon, Dr. Dempsey, who under trying conditions performed a quick tracheotomy, and unquestionably saved the patient from suffocation.

This method of application is not applicable with advantage to cancer beginning in the pyriform sinus or cancer of the epiglottis. In cancer of these locations it is wiser to insert individual tubes, again making use of the barbed hooks to retain them in place. In two cases of cancer of the epiglottis we have secured a total clinical retrogression by this means. A special form of forceps is necessary for the introduction of the tubes into the larynx. We have made use of a right angle pair of forceps, which carries a guard for the hook, that can be pulled off the hook when the tube is in position over the place at which it is desired to fasten it. It is a comparatively easy matter to fill the pyriform sinus with these tubes, or to cover the whole epiglottis with them. Cancer of the pyriform sinus should be regarded as cancer of the esophagus, and in addition to the insertion of these individual tubes, a chain of tubes should be placed within the entrance to the esophagus.

Cancer of the Esophagus

Of almost equal interest with cancer of the larynx is cancer of the esophagus. This is a form of epithelioma which, with cancer of the larynx, should offer peculiar opportunity for successful treatment by radium. Both diseases ought to be diag-

nosed in an early stage. Cancer of the larynx, except when it occurs in the pyriform sinus, gives symptoms when the growth is in an early stage. Cancer of the esophagus as a rule gives symptoms in an early stage. The first symptom is almost always dysphagia, and as a rule the patient can put his finger on some particular day when it began. At this stage the disease is almost always well localized, and involves but a short segment of the esophageal wall. It should be possible, by inserting a chain of radium tubes through the lumen of the stenosed tract, to successfully treat the whole disease, and provided the mediastinal glands are not involved, to radiate very uniformly the whole of the disease. It was, therefore, with much enthusiasm that we started the treatment of cancer of the esophagus.

The problem is not, however, a simple one, and our results have been most disappointing. This unquestionably has been due to two causes. The first of these is the selection of an improper dose, and the second cause is the failure to receive patients during an early stage of their disease.

Unquestionably some cancers of the esophagus originate in inclusions of embryonal epithelium, isolated at the time of the separation of the trachea from the esophagus, and forming little canals or cysts embedded in chiefly the anterior esophageal wall. In these cases the growths begin beneath the mucous membrane in the substance of the esophageal wall, and are, therefore, in their incipiency deep growths.

Perhaps there is no region of the body where the selection of just the right dose is of greater importance. The rapid decrease of the radio-activity at increasing distances from the tube, a decrease nearly proportional to the square of the distance, makes it necessary to furnish an exposure which will effectually irradiate the whole infiltrated portion of the esophageal wall. The normal esophageal wall is, however, very thin, and there is not, as in the case of the uterus and prostate, a comparatively indifferent tissue surrounding the disease. There is only a thin muscular and thin serous coat which, if too badly injured by radium, may necrose and perforate.

In looking back over the esophageal cases which we have treated we are certain that this has been the cause of death in a number of patients. Another difficulty is an interference with the power of the stomach to empty itself. In two patients the

evidence that this was the cause of death was very strong. This condition probably is due to a destruction of the conductive functions of the vagus nerve. It is certain that either the radium has a direct action upon this nerve, or that it becomes involved by the new growth of connective tissue and carcinoma cells at the site of the disease.

Finally there are the difficulties of accurately making the applications to cancer of the esophagus. At first we used one long tube, shaped like an hour glass, planning that the tumor should hug the narrow portion of the tube sufficiently securely to cause it to remain where it was placed. They were, of course, always inserted through the esophagoscope. We became, however, quickly dissatisfied with this method, as the tubes did not stay where they were placed. We then relied upon a wire attached to the tube, and held by the teeth to retain the tube in place within the epitheliomatous tract. This method gave some improvement, but it did not insure the intimate exposure of the whole tract. We then tried a chain of tubes, contained in a long rubber tube, or better in a silk woven catheter, suspended by a string tied to the teeth, or better yet by a wire held in place by the teeth. This method has given some very marked improvements. In fact the patient showing the most improvement to date was treated by this method. This was a patient upon whom a subsequent esophagoscopic examination showed the absence of nearly all ulceration, and a lumen through which it was easily possible to pass the esophagoscope. The esophagoscope was passed right through the former site of the lesion down to the stomach, and detected practically no abnormality of the mucous membrane. The patient, who first had marked dysphagia, now eats everything. We have classified him as a clinically complete retrogression, and are hoping that he will ultimately prove such.

It is most essential in these patients to make an esophagoscopic examination. Only by this means can an accurate diagnosis be made, and many facts about the character of the lesion, its size, the diameter of the lumen through it, and the length of the growth, be appreciated. If treatment is given without a preliminary gastrostomy, it is most necessary to insert the tubes of the radium with the aid of the esophagoscope. It is quite obvious that, if one end of the applicator is too high or too

low, only a portion of the growth will receive the exposure. This portion, once treated, cannot be treated a second time with the same freedom, so that once the case has been only in part efficiently treated, it is spoiled to a certain extent for an efficient treatment to the remaining portion. Unquestionably the safest method of treating cancer of the esophagus is with the aid which a gastrostomy furnishes, and particularly the form of gastrostomy which we have made use of in these cases.

If this operation is performed, a string, one end of which is swallowed through the mouth, can be pulled out through the gastrostomy opening with the aid of a small endoscope ten days after the operation. By means of this string a flexible chain of radium tubes can be pulled through the stenosed tract. The tube on the oral end of this chain is of larger size than the other tubes, so that it will not slip through the tract, but rest upon the top of the carcinoma. The slack in the aboral end of the string is then taken up and the end fastened to the abdominal wall. By this means an accurate relation of the tubes to the whole carcinoma can be established, and a uniform exposure to the radium given. Moreover, it is in some cases possible to examine the lower end of the cancer through the gastrostomy wound, and to obtain exact information regarding not only the lower end of the cancer, but also its exact size, and the response of the whole growth to treatment.

When the treatment of cancer of the esophagus was first begun, it was assumed that it offered somewhat the same favorable conditions for treatment as cancer of the uterus, and, to a lesser degree, cancer of the prostate. That inasmuch as it seemed probable that radium could be inserted so accurately within the center of the growth, the growth itself would form a protection against the serious effects of overdosage, and because of this fact, prolonged, and therefore, complete or far-reaching treatment could be administered. There is no question, for instance, that tumor tissue can be used as an effective filter, making possible longer lasting treatments, without the danger of overexposure to the normal tissues.

No clearer illustration of this fact could be offered than cases M. B. No. 24102 and Bryson.

In each of these cases a tumor was present of considerable thickness. It received an exposure which could not have failed

to produce the most serious consequences to normal tissues. As it was, the tissues receiving this heavy blow were alone the malignant tissues, and their complete death caused only their rapid disintegration and absorption, not their partial destruction and separation by a slow process of sloughing, as would have been the case if the normal tissues received any of this dose. It is solely because cancer of the cervix uteri can be treated with such massive doses, because, in other words, there are wide limits in the margin of safety in the treatment of cancer of the cervix uteri, that such good results have been obtained so early in the treatment of this form of cancer by radium.

In other regions of the body, however, only the most disastrous results will follow such attempts at centralized massive dosage. Being influenced by the promising results following treatment based on centralized massive dosage in cancer of the lip and cervix uteri, and the incomplete results of less dosage, it was natural for us to attempt to apply the same principle in cancer in other locations. A review of all of our case reports of cancer of the tongue, of the antrum, of the larynx, and of the rectum will only too impressively demonstrate that in these locations another principle providing for the wide distribution of the radium must be adopted to reach the more distant portions of the disease.

Our experience in cancer of the esophagus has only too sadly demonstrated the necessity for the greatest care in adjusting the dose to the growth. If, for instance, we could count upon the esophageal wall at the level of the growth being uniformly thickened by the tumor, or if the esophagus was surrounded, as the mucous membrane of the cervical canal or cancer of the prostate, by a thick, resisting tissue, it would be safe to make use of strong centralized radiation. As it is in the more favorable growths, the esophageal wall is not uniformly thickened. In fact, the ulceration upon its internal surface may have actually made the wall thinner than normal. Spontaneous perforation of the esophagus is one of the usual ways in which cancer of the esophagus may terminate life. Such a perforation may be not only into the pleural cavity, but into the bronchi, the heart, the aorta, or into the great veins. Preceding such a perforation the wall of the esophagus, at the point of perforation, is of

course very thin. In fact, depending alone upon the natural course of cancer of the esophagus, the pleura or the auricle or great veins, or the aorta, may form the actual base of the carcinomatous ulcer. Under such circumstances it is easy to see how even a very mild application of radium might be followed by serious consequences. We have, moreover, evidence that the heart muscle may be peculiarly sensitive to the action of radium.

In one patient (Hosp. No. 21785) of cancer of the esophagus, who died of inanition from an apparent failure on the part of the stomach to empty itself, there was found at autopsy at the site of the lesion a complete disappearance of all malignant tissue, but a large ulcer, caused by the radium treatment, occupied the anterior wall of the esophagus. The base of this ulcer was formed by the left auricle of the heart, which at this place showed beginning necrosis. A carcinomatous lymph node was found above the level of the lesion. The thin esophageal wall of the esophagus opposite to this ulcer was not necrotic, and the pleural covering was normal, although it had been as intimately exposed to the radium. It seemed, therefore, in this case that the auricle of the heart must have originally formed the base of the carcinomatous ulcer.

But quite apart from the thinning of the walls of the esophagus, which has been invaded in this manner by cancer, it is impossible to completely cover cancer of the esophagus by radium, that is, to introduce a series of applicators through the whole length of the disease, without exposing the normal esophageal wall as well. No cancer of the esophagus should, therefore, be exposed to a dose which is too great for the normal esophageal wall. In some instances even such a dose will be followed by an accident; for what makes perforation of the esophagus in its ulcerative lesions so likely and so dangerous, is the constant variation of the negative pressure within the pleural cavity just outside its walls.

It was only natural in the earlier experiences with the esophagus that we should have used doses which had been so successful on the lip or in the mouth. Trial, however, demonstrated that it is unsafe in cancer of the esophagus to trust to the filtering power of the cancer cells.

To sum up, there are many considerations making the treat-

ment of cancer of the esophagus a most difficult matter. There are the difficulties of accurate application, the necessity of careful adjustment of dosage, and the danger of perforation. We believe that radium has, nevertheless, a wide field of usefulness in cancer of the esophagus. Every case must be carefully studied before treatment is given. Only disaster will follow the attempt to cure advanced cancer of the esophagus by strong radium treatments. The almost certain presence of metastases in the regional lymphatics will defeat these attempts in the advanced cases, if a complicating perforation does not do so. The findings of a preliminary esophagoscopic examination are of the utmost importance for the purpose of estimating the extent of the disease, its location and its length. A good radiograph is of equal assistance. Crumps' method of radiographically determining the length of the lesion is also of service in selected cases.

If then a fairly early lesion is discovered, it can be treated by placing through the center of the growth with the aid of the esophagoscope a series of tubes enclosed in a silk woven catheter. These may be held in place by a wire possessing the spring and rigidity of the number 59 drill wire, which is attached to the proximal tube and held between the teeth. The exposure should be 120 to 140 m.c.-hrs. for each tube, containing 30 to 35 m.c. The duration of the exposure may be 4 hours. If the case is an early one better results will be obtained by the use of 2 mm. lead tubes and an exposure of 180 to 200 m.c.-hrs. for each tube or 6 hours for tubes containing 30 to 35 m.c.

If a somewhat more advanced lesion is discovered a gastrostomy should be performed, and the lesion treated by pulling a series of tubes into place, by a previously swallowed string delivered by a small gastroscope through the gastrostomy opening, and the use of approximately the same dose. Even in a lesion which is still more advanced a treatment by this method, by the use of a shorter exposure, is indicated. Though the regional lymphatics in these more advanced cases are apt to be involved, yet the palliative benefit to be derived from one such radium treatment is far more than can ever be hoped for from a dilatation by bougies.

Almost each case of cancer of the esophagus has taught us some important lesson regarding the treatment of the disease.

It is a lesion so easily diagnosed by esophagoscopy, when once suspected, that no excuse can exist for a failure to recognise the disease upon the first symptom of dysphagia. The vast majority of our cases have had symptoms for several months before being referred to us. Even in many of these cases the lesion was still circumscribed.

In this stage the favorable results of the treatment of similar forms of epithelioma elsewhere justifies the view that esophageal cancer can be cured by radium. The series of cases here reported by no means justify a gloomy outlook in this form of cancer. Even this series demonstrates that cases too late for a cure by radium treatment can receive a palliative relief (produced in eight of our cases) and a longer extension of life than by dilatation or any other palliative procedure.

We have treated 22 patients with cancer of the esophagus. Only one of these has been benefited sufficiently to encourage the belief that a complete retrogression has taken place. This patient was treated first on June 7, 1916. On July 24 he was able to eat everything and was free from all discomfort. An esophagoscopic examination revealed an almost complete healing of the ulceration, and a return of the lumen to almost its normal patency.

On September 6, fearing the persistence of some disease, a second treatment was given. Unquestionably this treatment was an error, and at least too long. Following the treatment there was a complete healing of all ulceration, but the development of a fibrous stenosis at the site of the original lesion, associated with a good deal of discomfort in the epigastrium. At present (June 25, 1917) a one centimeter olive can easily be passed through the stenosis, and the patient swallows well.

Five other cases of cancer of the esophagus, now dead, have been definitely improved, and one other case, still living, improved notwithstanding the presence of an advanced lesion at the time the treatment was given.

The fifteen remaining cases were not improved. The failure to secure a better result in more of these patients is due partly to the large size of the original growth and, as we now feel, to the too frequent repetition of the treatment.

The following is the clinical record of the single case of

cancer of the esophagus in which the lesion has apparently completely retrogressed:

Case P. MacN. Hosp. No. 23274. Male, 62 years old.

Cancer of the esophagus. An apparently complete objective retrogression, with relief of dysphagia to date, produced by two treatments.

Condition on Admission, June 7, 1916.—Almost complete dysphagia. The patient could swallow liquids with the greatest difficulty. Esophagoscopic examination shows an ulcerated nodular growth 14½ inches from the incisor teeth, producing a stenosis of the esophagus. The nodules and walls of the stenosed tract are very hard.

History.—The first symptom was dysphagia, which was noticed one year ago. It has increased gradually and been accompanied with a progressive loss of weight. The patient is still, however, fairly well nourished. Denies syphilis. Previous health has been good.

Treatment.

June 7, 1916: 5 tubes; 475 m.c.; 1½ mm. platinum covered with rubber; directly; 4 hrs.

July 24, 1916: The lesion has apparently almost completely retrogressed. The mucous membrane is smooth and only at one place is there a small amount of induration. The esophagoscope could be easily passed through the former stenosed area beneath which no disease was present.

Aug. 9, 1916: The patient eats everything without difficulty.

Sept. 6, 1916: Local condition essentially unchanged, but a small ulcer detected, another treatment decided upon for prophylactic reasons.

Sept. 6, 1916: 5 tubes; 165 m.c.; 1½ mm. platinum covered with rubber; directly on a wire; 6 hrs.

Sept. 20, 1916: Slight pain in chest, but feels well and eats everything.

Dec. 6, 1916: Mucous membrane normal, with exception of a small healed cicatrix at site of old lesion. Absolutely no ulceration present. Eight millimeter obturator slips through without slightest difficulty. Complains of pain in region of sternum, especially when taking food.

Jan. 24, 1917: Daughter reports stricture of the esophagus

seems to be increasing, discomfort less and the general condition about the same.

Jan. 28, 1917: An olive 1 cm. in diameter easily passed. Patient swallows well. He complains at present of more or less gastric distress, at times very severe, after eating. His general condition is fair.

June 16, 1917: Condition the same.

Cancer of the Stomach

Cancer of the stomach offers a tempting field for the use of radium. It is rarely discovered in a stage which permits of cure by operation. The more advanced cases are greatly relieved by gastro-enterostomy. In well established cancer of the stomach, which still comes within the limits of operability, cancer which is freely movable and capable of being lifted well up out of the abdomen, life can unquestionably be prolonged by gastrectomy.

But even in the majority of such patients the increased length of life which can be offered to the patient by a gastrectomy over and above the increased length of life which a posterior gastro-enterostomy will give is not very great, and can only be accomplished at the expense of a very much greater risk. A posterior gastro-enterostomy can easily be performed under local anesthesia, and is practically devoid of risk. It becomes, therefore, an important question whether the combination of radium treatment with a posterior gastro-enterostomy in all but the most favorable cases for pylorectomy is not the procedure of choice.

With this belief in mind we have treated seven patients with cancer of the stomach with radium, three of these with the combination of a posterior gastro-enterostomy and radium. All these patients have been much improved, but it is of course doubtful how much the radium exposures have had to do with the improvement apart from the gastro-enterostomy alone.

The four remaining patients had very advanced cancers, and have been treated merely through the abdominal wall. None of them has been essentially improved.

The following is the case record of one of the improved patients with cancer of the stomach:

Case J. S. Hosp. No. 23889. Male, 57 years old.

Cancer of the pylorus. Posterior gastro-enterostomy. Later treatment of the cancer by radium, applied both internally and externally.

Condition on Admission, June 27, 1916.—He complains of considerable epigastric pain, of loss of much weight, 80 pounds in the last year, and of persistent vomiting. At the present time he retains practically nothing on his stomach. The vomitus contains food remnants swallowed 24 to 48 hours previously. He has never vomited blood. His hemoglobin is reported to be 20 per cent. and the red cells 2,000,000. He is very weak. In the upper epigastric region an indefinite resistance can be felt on firm deep pressure. Radiographs show complete pyloric obstruction.

Mx: Adenocarcinoma.

History.—Four months ago he first felt pain in the abdomen after eating. He began at the same time to vomit, and the vomiting increased up to the present time. He will sometimes vomit two quarts, and the vomitus often contains brownish-colored material.

Treatment.

On July 1 the patient was given 1 quart of blood from his wife. This raised his blood count to 4,000,000 and the hemoglobin to 40 per cent.

On July 3 a posterior gastro-enterostomy was performed, and a tumor was found which completely surrounded the pylorus, but did not involve the duodenum. It was hard and nodular, and about 3 inches in length. A few hard nodules were found in the lesser omentum, and one or two subserous nodules in the anterior wall of the stomach, 1 inch from the main mass.

On Aug. 5 the abdomen was again opened and 125 m.c. of radium, divided into 5 tubes, was inserted into the center of the cancer and tied to a previously swallowed string. It was retained in place by the loop in the upper tube, and removed after 10 hours by the previously swallowed string, to which it had been tied.

Following these operations the patient has progressively improved.

On Nov. 2 he had gained in weight and his hemoglobin was

50 per cent. He was free from pain in the abdomen and much stronger.

Dec. 2, 1916: 12 plaques; 800 m.c.; 3 mm. lead, 2 cm. wood, 1 cm. gauze; to both sides of abdomen; 18 hrs.

Jan. 12, 1917: General condition good. No tumor palpable. The superficial erythema of the skin in the area treated has practically disappeared.

Mar. 14, 1917: Absolutely no tumor can be felt in the abdomen. General condition excellent.

A good deal of temporary relief, particularly from pain, can often be accomplished by treatment through the abdominal wall.

The following case record illustrates this fact:

Case J. M. Hosp. No. 23966. Male, 46 years old.

Advanced cancer of the stomach. Much subjective relief (principally a diminution of pain) from one external application.

Condition on Admission, December 4, 1916.—A large mass can be palpated in the upper epigastrium through the abdominal wall. It is nodular and hard and its position indicates that it is growing in the stomach wall.

History.—In December, 1915, he began to have pain and distention in the epigastrium after eating. His pain became worse and the patient lost 50 pounds. In Mar., 1916, the pain began to be quite severe at night, awakening him. He became weaker and stopped work in May on account of weakness. He was operated upon on June 13, 1916, and cancer of the stomach was discovered. Following the operation he did fairly well but gained no flesh or strength. He ate little and frequently vomited black material. Meantime the pain has increased in severity, and his inability to eat without vomiting more pronounced. At present he is very weak and vomits often. Aside from typhoid fever at 18, he has been well and denied venereal disease. There is no history of cancer in the family.

Treatment.

Dec. 10, 1916: 12 plaques; 480 m.c.; 2 mm. lead, 3 cm. distant; over the epigastrium; 18 hrs.

Feb. 1, 1917: A telephone communication during the first

week of February, stating that his pain had diminished so much and his general condition has so improved that a second treatment was desired. The tumor is smaller.

Feb. 18, 1917: 12 plaques; 660 m.c.; 2½ mm. lead, 3 cm. distant; over the epigastrium; 13 hrs.

Cancer of the Rectum

Cancer of the rectum may be classified histologically into two forms: The adenocarcinoma of the rectal mucosa, and the epidermoid carcinoma of the anal region. In our experience both these forms, but especially the adenocarcinomata, have shown a marked susceptibility to radio-activity. The problem in cancer of the rectum is not so much a question of susceptibility of the growth to radio-activity as it is a question of technic of application.

The desirability of successfully treating cancer of the rectum by radium is great. The operative results in this disease are poor, and the operation is very mutilating. In many cases it becomes necessary to establish an artificial anus, many operators refusing to undertake the operation without this permission. Even in many of the early cases the establishment of an artificial anus is a condition of success. The prospect of an artificial anus is so disagreeable to many patients that operation is often refused upon these grounds alone.

The difficulty of satisfactorily applying radium to cancer of the rectum is greater than it would at first sight seem. When we first began the treatment of these patients the only method available was the insertion of a single radium tube within the rectum, or within the stenosed canal leading through the carcinoma. The impossibility of accomplishing anything by such an inaccurate method soon became apparent. The radium or its emanation must be divided into separate tubes, and these enclosed in line with each other in one long rubber tube or silk woven catheter. This method is very much better, and is really the only method which can be used when much stenosis is present.

In the more advanced tumors unlooked for results may sometimes be accomplished by initial long exposures with such a chain of tubes. A case now in the hospital is an illustration of

a really remarkable result accomplished by this method. When this patient entered the hospital he had a tumor of huge size. Yet eight months after the treatment no abdominal metastases could be discovered at an operation for ileostomy, and at the present time there is no evidence that his disease is active.

In the case of the earlier and more favorable growths this method is not productive of the best results. It is too inaccurate. It must be remembered that the cavity of the rectum is large and that a string of tubes inserted through its lumen will not necessarily fall into intimate relation with all parts of the tumor in the rectum, but far more likely will lie against some other portion of its wall. Of course, that portion of the wall in most intimate contact with the tube will receive the heaviest fire. Under these conditions the tumor is very likely to receive an insufficient treatment, while the normal mucosa of some other portion of the rectal wall may receive enough to cause a radium inflammation, or at least be rendered less resistant to subsequent treatments.

It is most desirable to adopt a plan of treatment which will insure the most intimate exposure of the whole of the tumor-bearing area, and, taking advantage of the large size of the lumen of the rectum, to protect the opposite walls. Such an end may be accomplished fairly successfully by introducing through a speculum a piece of muslin to which a considerable number of tubes are sewed or tied. Such a piece of muslin carrying the tubes may then be easily spread out over the tumor with the aid of the speculum; and then over this muslin, in order to separate the opposite rectal wall, packing may be introduced. We have successfully used this method of treatment in several recent cases. A still more accurate method is to make a mold of the cavity of the rectum of dental composition and embed the radium tubes on its surface opposite the lesion. In one patient with a small growth situated high up in the rectum we most successfully placed a little pan covered with radium tubes and screwed to the back of a small proctoscope upon the growth, utilizing direct observation through the proctoscope to insure accurate placing. The proctoscope with attached pan was left in place during the whole period of application.

Not infrequently it becomes difficult to insert a chain of tubes through the carcinomatous tract in some of the more

advanced cancers of the rectum, and yet patients with even these advanced tumors may be greatly benefited by treatment. The difficulty usually depends upon the buckling of the tube in a tract which is somewhat tortuous. In such patients the growths are almost always advanced and obstruction so imminent that a colostomy is indicated.

In these patients we have divided the upper sigmoid completely through an incision on the middle line, and then delivered both free ends through separate small incisions in the rectus muscle, merely the fascia of the muscle being incised and the fibers separated bluntly. Such an operation gives a good functionating artificial anus. Eight to ten days after it a string can be washed through the lower segment and out of the anus. By this string a chain of emanation tubes may be safely pulled through the stenosis, and total length of the cancer thus treated.

The tumors at the anus are usually epidermoid carcinomas. They are more malignant and less susceptible to radium than the majority of the adenocarcinomas. Metastases frequently form from them in the inguinal lymphatic glands, a feature which greatly diminishes the prospect of cure.

When diagnosed and treated early, before any metastases have occurred, the prognosis is good. Little excuse exists for failing to diagnose epithelioma of the rectum in an early stage, as patients almost always notice these growths in a stage which is relatively early. At this time the growths are frequently mistaken for hemorrhoids, an error which is often shared by the first medical advisor whom they seek, and one which has cost many a patient his life.

Epithelioma of the anal region is easily managed by inserting a chain of relatively few tubes within the anal canal, and anchoring the most external over the growth by adhesive plaster. If the external portion of the tumor is more extensive it should be covered by a cloth applicator of sufficient number of tubes to completely cover the growth. Still larger external growths are best treated by distance applicators.

The same principles should control the management of the inguinal glands as controls the management of the deep cervical glands in cancer of the mouth.

We have treated altogether thirty-four patients with cancer of the rectum. Of these two have completely retrogressed and

show no evidence of disease at the present time. Fourteen have been improved, while eighteen have been classed as unimproved.

The summary of the clinical record of the two retrogressed patients is as follows:

Case F. L. Hosp. No. 23724. Male, 55 years old.

An early carcinoma of the rectum. Apparent complete clinical retrogression after three treatments. A residual stenosis insufficient to materially interfere with defecation of undeterminable character.

Condition on Admission, June 7, 1916.—Three inches above the anus, on the anterior right aspect of the rectal wall, there is a freely movable, flattened tumor, about 1¼ inches in diameter. The surface of the tumor bleeds easily and is covered with irregular papillary-like nodules.

History.—His first symptom was bleeding from the rectum eight weeks ago. He has not been constipated nor lost weight.

Treatment.

June 7, 1916: 5 tubes; 500 m.c.; 1½ mm. rubber-covered platinum; applied directly through a speculum and hooked to the surface of the tumor through the speculum; 2 hrs.

July 18, 1916: 5 tubes; 200 m.c.; 1½ mm. rubber-covered platinum; applied directly through a speculum and hooked to the surface of the tumor through the speculum; 4 hrs.

Sept. 19, 1916: 8 tubes; 248 m.c.; 1 mm. rubber-covered platinum; 4 in a long rubber tube and 4 applied separately to the tumor; 6 hrs.

Jan. 1, 1917: Following each of these treatments the patient has had a moderate amount of discomfort, due to the radium. There has been a definite retrogression of the tumor mass, but accompanying it the development of fibrous-like stenosis at the level of the lesion, through which the index finger can be just about inserted. The stenosis at present does not seriously interfere with defecation.

Mar. 15, 1917: Letter from one of the surgeons originally examining the patient stating that the original growth had disappeared, at least as an ulcerated indurated lesion. The remaining thickening of the rectal wall feels like cicatrix. It is, of course, possible that it contains inactive tumor tissue.

Case F. C. Hosp. No. 23198. Male, 65 years old.

Fairly early adenocarcinoma of the rectum. Apparently complete clinical retrogression after two treatments. Later recurrence and death.

Condition on Admission, May 10, 1916.—Prolapsing through the anus is a large mass of internal hemorrhoids, completely surrounding the circumference of the bowel. Two inches inside the sphincter, on the left rectal wall, is a flattened, indurated tumor about 1 x 1½ inches in diameter. The surface is covered with indurated nodules.

Mx: Adenocarcinoma.

History.—For many years he has been afflicted with hemorrhoids. Last December the bleeding from the rectum increased, and the local discomfort, which he attributed to the hemorrhoids, became increased. He now suffers from quite a little pain in the rectum at night.

Treatment.

May 13, 1916: 3 tubes; 300 m.c.; 1.5 mm. rubber covered platinum; hooked upon ulcer through a speculum; 4 hrs.

May 31, 1916: There is an entire disappearance of the tumor.

June 14, 1916: There is no evidence whatever of the growth.

Dec., 1916: Evident tumor growth to one side of the mass of hemorrhoids at the anus. High up, 4 inches within the rectum, there is a stenosis of the rectum which is ulcerated at one place, and covered with a slough.

Microscopical examination of a fragment of tissue removed on two occasions from this ulcer showed an absence of cancer tissue. The stenosis and ulcer feel like a late radium effect.

Jan., 1917: An apparently complete retrogression of the malignant disease at the anus and complete healing of the ulcer in the rectal wall above the anus. The external hemorrhoids operated on.

Mar. 1, 1917: No definite clinical evidence of the presence of disease. It is possible that remnants of carcinoma tissue still remains in the cicatrices.

Case M. H. Hosp. No. 23715. Female, 58 years old.

Carcinoma of the rectum. Complete disappearance of all tumor tissue following one treatment.

Condition on Admission, September 16, 1916.—The anterior half of the anal ring is surrounded by hemorrhoidal-like nodules. These are hard and continuous with a flat infiltration of the anterior rectal wall extending 2½ inches upward into the rectum. The surface of the indurated portion of the rectal wall is ulcerated and covered with minute neoplastic nodules which bleed easily when traumatized. The entire thickness of the rectovaginal septum is infiltrated. The vaginal mucous membrane is not involved, or ulcerated, and is freely movable over the mass in the rectum which can easily be felt as a prominence through it.

History.—One year ago she noticed blood in the stools and the presence of small nodules on the outside of the anal ring. She also had much burning in the rectum and a constant desire to defecate. During the past year she has lost 40 pounds in weight and has suffered with pain in the leg. There has been no bladder disturbance.

Treatment.

Sept. 23, 1916: 7 tubes; 270 m.c.; 1 mm. lead; in the rectum; 6 hrs.

3 plaques; 150 m.c.; 3 mm. lead; in the vagina; 6 hrs.

Nov. 5, 1916: There has been a complete disappearance of the lesion, with the exception of a small cicatrix-like induration.

Feb. 2, 1917: Prophylactic treatment; 3 tubes; 111 m.c.; 2 mm. lead, 4 mm. rubber; in the anus; 4 hrs.

May 2, 1917: A somewhat nodular thickening of uncertain character is still felt in the rectal wall just above the anus.

May 12, 1917: 4 tubes; 148 m.c.; 2 mm. lead, 1.7 cm. rubber; 4 hrs.

Among the improved patients eight are still living, and of these eight one was first treated May 12, 1914. At the present time all that remains of his lesion is an indurated cicatricial area of uncertain character in the rectal wall. It is possible that he has no malignant tissue present. The same statement may be made of another patient treated first in June, 1916. Four of the other six patients are still under treatment, and are doing well.

Another of the improved patients, now dead, was first treated

in Feb., 1914. The lesion in the rectum disappeared, and an examination in May, 1916, discovered no recurrence. She died in Jan., 1917, without a return of rectal symptoms, or any definite indication of visceral metastases. For the last two years of her life she has had a very severe chronic arthritis, and there is no more reason to assume that the carcinoma of the rectum caused her death than her chronic arthritis.

The character of improvement is illustrated by the following clinical records:

Case E. J. Hosp. No. 23047. Female, 50 years old.

Moderately advanced cancer of the rectum. Local improvement following treatment, and later metastases in the liver.

Condition on Admission, April 3, 1916.—About 2½ inches above the internal sphincter there is a circular ulcer upon the posterior left lateral wall of the rectum. It is approximately 1½ inches in diameter. The base and margins of the ulcer are indurated, and the surface is uneven and covered with small papillary-like nodules.

History.—During Aug., 1915, she began to suffer from alternating constipation and diarrhea, accompanied by a disagreeable bearing-down sensation whenever the bowels moved. These symptoms have increased, and there is now added at times an actual pain in the rectum. No blood has come from the rectum, with the exception of one occasion, four weeks ago, following an examination. She has lost 25 pounds in weight.

Treatment.

Apr. 3, 1916: 3 tubes; 300 m.c.; 1½ mm. platinum and rubber; inserted through a speculum and pinned to the surface of the ulcer, separately by the hooks; 4½ hrs.

June 7, 1916: Whole growth diminished in size, but at the site of the application a dense stenosis of the rectum has developed, through which the finger can be inserted with difficulty. The patient has suffered rather severely from inflammation caused by the radium.

July 29, 1916: 4 tubes; 140 m.c.; 1½ mm. platinum in rubber inserted through the stenosed area in a single rubber tube; 4 hrs.

Nov. 4, 1916: There is still present a dense stenosis, the walls of which seem formed of dense neoplastic tissue, and are

in part nodular. The finger can be introduced somewhat more easily and the total mass of the tumor does not seem so large.

Jan., 1917: Visited. The margin of the liver could be palpated three finger breadths below the costal border, and the patient had lost much strength. At the site of the primary lesion in the rectum the stenosis was still present. It admitted the index finger; the mucous membrane covering it was smooth and free from nodules. The patient was not especially constipated and defecation was not uncomfortable. She complained of no local discomfort whatever. Apparently the treatment had eliminated symptoms of the disease at its primary site, if not the primary growth itself, the patient ultimately doing badly from visceral metastases alone.

Case J. W. Hosp. No. 21371. Male, (?) years old.

Cancer of the rectum. Treated at first with 16 mild treatments, frequently repeated. Finally a recurrence treated with one very strong treatment. This was followed by an apparent complete retrogression.

Condition on Admission, May 12, 1914.—One inch above the internal sphincter there is an indurated flattened mass, 1½ inches in diameter. Its surface is nodular and ulcerated.

History.—Three years ago he had an uncomfortable sensation when the bowels moved. The discomfort gradually increased and he became constipated. Twelve months ago he began to have bleeding from the rectum. He denies syphilitic history, and has always been in good health previously. From May 12, 1914, to Jan. 1, 1915, he received 16 treatments, with 8.7 m. grams for 4 and 5 hours at a time. This treatment produced a fairly complete retrogression, but a recurrence took place, which was first detected in May, 1915.

Treatment.

May 8, 1915: 1 tube; 100 m.c.; 1.5 mm. lead, 2 mm. rubber; within the rectum; 24 hrs.

Aug. 10, 1915: There is a disappearance of all tissue resembling the tumor. Only a small indurated area which feels like a cicatrix remains in the rectal wall.

Feb. 26, 1916: 3 tubes; 3 m.c.; 1.5 mm. platinum and rubber; in the rectum; 12 hrs.

Following this treatment, which was given because the indu-

ration in the cicatrix had taken on a more suspicious character, a severe reaction developed, but the patient was seen in the late fall and no evidence of disease could be demonstrated.

Feb. 13, 1917: He wrote that he was perfectly well.

All of the eighteen unimproved patients had very advanced or recurrent growths, with the exception of two patients. In one of these patients the tumor completely retrogressed, but the patient was overtreated, and developed in consequence a very painful fissure in the rectum. This made her so uncomfortable that a colostomy was performed, from which operation, in her reduced condition, she did not recover.

The second patient had a circumscribed lesion, which at the present time we believe could be made to disappear. He was treated early in our experience by the insertion of a single tube, which produced practically no effect on the course of the disease.

The following case record is illustrative of the unimproved set of cases:

Case T. MacG. Hosp. No. 23320. Female, 60 years old.

Large carcinoma of the rectum, previously tampered with. Rapidly progressing to death within a very short period, following two treatments.

Condition on Admission, April 20, 1916.—On the left posterolateral aspect of the rectal wall, just inside the sphincter, is a very bulky tumor. Estimated by the finger it is 2 to 2½ inches in diameter. The tumor deeply involves the rectal wall, so that it seems ulcerated chiefly upon a portion of its surface. A large portion of the tumor is growing beneath the mucous membrane.

History.—The first symptom noticed by the patient was bleeding from the rectum and a bearing-down sensation ten weeks ago. Two weeks ago she was operated upon, under the impression that she had hemorrhoids, and a microscopical fragment of tissue removed at this time showed carcinoma.

Treatment.

Apr. 20, 1916: 3 tubes; 100 m.c.; 1.5 mm. rubber-covered platinum; pinned separately to the tumor through the sphincter; 4 hrs.

May 8, 1916: The patient has been through a considerable

period of discomfort, pain and tenesmus. She is now more comfortable, and there is a very considerable reduction in the size of the tumor.

June 13, 1916: The growth has begun to increase in size.

June 13, 1916: 5 tubes; 400 m.c.; 1.5 mm. rubber-covered platinum; within the rectum; 2 hrs.

Following this treatment her general condition gradually deteriorated, without a corresponding change in the size of the tumor.

July 4, 1916: Exitus.

Cancer of the Penis and Vulva

Seven patients with cancer of the penis and one patient with cancer of the vulva have been treated. In three of the patients with cancer of the penis the disease at one time appeared to have completely retrogressed.

In one of these four patients the diagnosis rests upon somewhat uncertain clinical grounds alone. Of the other two patients, one is now under observation, because of the reappearance of a suspicious nodule, the nature of which at present is uncertain, but the possibility of a recurrence cannot be excluded.

One patient was treated prophylactically after a local operation, and is still well. One patient has been greatly improved by treatment, but has been lost sight of, so that his present condition is unknown. Two patients have been unimproved.

The only patient with epithelioma of the vulva was not only a failure, but she did not seem to have a very advanced lesion, 1½ inches in diameter, when she was first treated. She received a strong treatment, with some temporary retrogression. In about two months after treatment glandular metastases developed, and both these and the primary tumor grew very rapidly.

Carcinoma of the Uterus

The majority of the patients with cancer of the uterus which have been treated at the Memorial Hospital are not included in this report. These patients have formed a separate service and will be reported later.

Ten private patients have been treated in the general service

and deserve special mention. Four of these have undergone an apparent complete retrogression. They were all on the border line of operability. Two had adenocarcinoma, one of the fundus, and one of the fundus and cervix, and two epitheliomas of the cervix. The result was accomplished in each of these patients with one application, although two of them received more than one treatment. The two most important patients, each having epithelioma of the cervix, received only one treatment. The smoothness of the post-treatment history left nothing to be desired.

In other words, four patients with cancer of the uterus, three of whom had moderately advanced cancer of the cervix, on the border line of operability, have undergone a complete clinical retrogression as a result of one radium treatment; a treatment involving no risk and, apart from the day of the treatment, not in any way interfering with the comfort or occupation of the patient.

Cancer of the uterus or cervix is one of the few locations in the body where a strong centralized treatment may be given with advantage. As has been explained the tissue of the cervix is a dense, thick, relatively unsensitive tissue. It bears doses of radium which are impossible of application elsewhere.

We believe that the best method of treating these forms of cancer is to insert as much as 300 m.c. within the cervical and uterine canal, and to pin additional tubes, containing 200 additional m.c. upon the external surface of the cervix. If then the vaginal walls are packed away with gauze, the emanation may be left in place for twelve hours without fear of bladder or rectal complications. Much depends upon the care with which the bladder and rectum are packed off. Nothing is to be dreaded more than the radium cystitis or proctitis, or what is even worse, a rectovaginal fistula. With the technic which we have used the treatment has caused a temporary mild catarrhal irritation in the rectum. We have considered it desirable to carry the treatment this far in order to insure the maximum distance effect. The filtration has always been heavy, 1½ mm. of rubber-covered platinum.

The following is the description of the condition and history of the four patients who have undergone a complete clinical retrogression:

Case C. C. Hosp. No. 21999. Female, 77 years old.

Admitted to the New York Hospital, Sept. 13, 1914.

Condition.—The uterus and cervix curetted. Both found to contain much soft tissue. Examination by the rectum showed that the growth had invaded the anterior rectal wall.

Mx: Adenocarcinoma of cervix and uterus.

Entered the Memorial Hospital Sept. 25, 1914.

History.—Twenty-five millicuries of radium emanation was inserted in the cervix for four hours. She left the hospital much improved. She returned in about two months. Not much improvement noted since previous treatment. The cervix is enlarged 1½ times its normal size and hard. More or less vaginal discharge. At present some restriction of the normal mobility of the cervix. The base of the broad ligament feels thickened.

Treatment.

Apr. 13, 1915: 1 tube; 50 m.c.; 1 mm. lead covered with rubber; in the cervical canal; 48 hrs.

Following this treatment there was a vesical and rectal irritation. Both these subsided in the course of a few weeks. The patient then steadily improved and became free from all symptoms of her disease.

Feb. 13, 1917: Examination revealed a small shrunken cervix, free from ulceration and no evidence of disease involving the broad ligament.

A few days before this examination she began to complain of a vague headache. About two weeks later she had pain and soreness in her right inguinal region, followed by tenderness over the right kidney region. The urine was scanty and high colored, and upon examination showed a large quantity of pus cells and bacteria. She had some nausea and vomiting, but no rise of temperature. Her general condition deteriorated rapidly and she died on Mar. 16, 1917.

Autopsy.—Autopsy revealed an abscess surrounding the lower pole of the right kidney with extension to the wall of the renal pelvis and beginning purulent interstitial inflammation of the kidney. The uterus is reduced to a nodule of tissue 2 x 1 x 1½ cm. and is surrounded by adherent intestinal coils and fused with bladder wall. The vagina is shortened and thickened but smooth. On section the uterus is found infiltrated by alveoli of adenocarcinoma or malignant adenoma, in which the lining

cells show hydropic degeneration but the nuclei stain well. Mitoses could not be found. The muscle tissue is extensively fibrosed. The rectal wall is fibrosed but free from cancer. The bladder wall is infiltrated by scanty adenocarcinomatous alveoli over an area 2 cm. in diameter, but the mucosa is intact.

Case A. S. Hosp. No. 23320. Female, 70 years old.

An early cancer of the body of the uterus. A complete retrogression after one treatment.

Condition on Admission, June 5, 1914.—The uterus is slightly enlarged. There is a bloody discharge from the cervix. The cervix itself is not enlarged or ulcerated. The patient is fat and suffers from some dyspnea on exertion. Her arteries are thickened and tortuous.

Mx: Adenocarcinoma.

History.—Five weeks ago the patient noticed a bloody discharge from the vagina, and an uncomfortable bearing-down sensation. Three weeks ago she began to have some pain in the back. These symptoms have gradually increased to date.

Treatment.

June 5, 1914: Under nitrous oxid the uterus was curetted, and the curettings showed on section adenocarcinoma. A tube containing a small quantity of radium was inserted into the uterus for 6 hours.

July 31, 1914: A second treatment with 20 m.c. of radium for 8 hours was given.

Following this treatment there was no return of the menorrhagia nor any uterine symptoms whatever. The patient died in the summer of 1916 of apoplexy.

Case M. F. Hosp. No. 23027. Female, 48 years old.

Operable cancer of the cervix. A complete retrogression following one treatment.

Condition on Admission, March 25, 1916.—The cervix is enlarged and its vaginal surface is ulcerated. The ulceration surrounds the external os, but does not reach the vaginal walls. The margins and base of the ulcer are raised, hard, and nodular. The body of the uterus is not enlarged.

Mx: Plexiform epidermoid cervical carcinoma. The cells show slight swelling, much nuclear hyperchromatism and homo-

genization of the nuclei. At some points there is a rich exudation of lymphocytes and polynuclear leukocytes, which encroach on the masses of degenerating tumor cells.

History.—The patient's attention was first attracted to her disease by intermenstrual bleeding and rather profuse menstruation during the past two months.

Treatment.

Mar. 25, 1916: 1 tube; 200 m.c.; 1½ mm. rubber-covered platinum; in the cervical canal; 16 hrs.

2 tubes; 200 m.c.; 1½ mm. rubber-covered platinum; on vaginal surface of cervix; 16 hrs.

Jan. 10, 1917: No evidence of disease present.

Case J. H. Hosp. No. 23521. Female, 52 years old.

Cancer of the cervix uteri, on the border line of operability, healed with a single application of radium.

Condition on Admission, July 31, 1916.—The cervix is considerably enlarged and very hard. The body of the uterus does not feel enlarged. Extending over the dorsal right portion of the cervix for a distance of about halfway to the reflexion of the mucous membrane to the vaginal wall is an ulceration with hard base.

Mx: Plexiform epidermoid carcinoma.

History.—She never considered herself strong, and has been very nervous since she passed through an attack of nervous prostration 18 years ago. She has had three children, and one miscarriage 29 years ago. Oldest child is 27, youngest 16. The births were normal. Her menses have always been regular, every 3½ weeks, unwell 5 to 6 days, flow profuse. From Apr. 15, 1916, to June 30 no menstruation. Then she was in bed with an intermittent flow for two weeks. After being up one week, started to flow again, and has had intermittent, moderate flow ever since.

Treatment.

July 3, 1916: 3 tubes; 300 m.c.; 1 mm. platinum covered with rubber; 1 in uterus, 2 on cervix; 12 hrs.

Sept. 20, 1916: Ulceration on outside of cervix almost healed. Cervix diminished in size and uterus healing. One week following treatment she had a hemorrhage similar to previous ones, lasting one day. Gradual diminution of discharge, and

no discharge of blood since. At no time any rectal or bladder symptoms. General health steadily improving.

Much can be accomplished with recurrent and late cases of cancer of the uterus.

The following clinical record is an illustration of this fact:

Case A. T. Hosp. No. 23730. Female, 53 years old.

Carcinoma of the anterior vaginal wall and later in the vault of the vagina, recurrent after hysterectomy. Complete disappearance of all ulceration in the vagina following treatment.

Condition on Admission, July 14, 1916.—Surrounding the meatus of the urethra is an indurated mass, 1 inch in diameter, which is continuous with an elongated extension beneath the anterior wall of the vagina about 1½ inches in length. The uterus is absent. The vault of the vagina feels free from disease.

History.—During Sept., 1915, she began to bleed from the uterus. The bleeding continued and increased in severity. In Mar., 1916, a panhysterectomy was performed. The patient's previous health has been good. She is stout and well nourished.

Treatment.

July 14, 1916: Several tubes; 100 m.c.; 1½ mm. rubber-covered platinum; to ulcer; 6 hrs.

Sept. 20, 1916: Several tubes; 240 m.c.; 1 mm. rubber-covered platinum; to ulcer; 2 hrs.

Oct. 16, 1916; 6 tubes; 180 m.c.; 1 mm. rubber-covered platinum; to lesion; 2 hrs.

Nov. 11, 1916: There has been a complete retrogression of the lesion surrounding the external meatus, but high up in the vault an indurated nodule has appeared and ulcerated.

Nov. 11, 1916: 6 tubes; 120 m.c.; 1 mm. rubber covered platinum: to center of ulcerated nodule, walls of vagina well packed off; 12 hrs.

Jan., 1917: The patient has lost much flesh and strength and complains of backache. She looks badly. A vaginal examination demonstrates the presence of extensive infiltration of the peritoneum surrounding the vault of the vagina. There is no ulceration in the vagina. Turned over to the *x*-ray department.

Two very advanced cases have been greatly improved, and are both still under treatment. Four advanced cases have not been materially improved.

The history of one of these advanced cases is as follows: Its significance to us lies in the fact that a preliminary cauterization is most undesirable in these advanced cancers of the cervix. Both operation and cauterization remove cervical tissue which forms such a valuable filter to the radium. With the cervix intact far larger and more effective treatments by radium can be safely given, and such treatments accomplish all that preliminary cauterization or operative removal accomplishes.

Case J. W. Female, 49 years old.

Very advanced cancer of the cervix. Cervix cauterized. One treatment with many tubes and short exposure. Practically no effect on the disease.

Condition on Admission, December 4, 1916.—The cervix is replaced with a deeply excavated ulcer. The walls of the ulcer are hard and deeply infiltrated both anteriorly and posteriorly. The whole thickness of the upper portion of the rectovaginal septum is infiltrated. The base of the ulcer is covered with a thick slough. The uterus is small and its mobility is greatly restricted. The broad ligaments are much thickened.

History.—Four years ago menstruation became irregular, and small intermenstrual bleedings occurred. These symptoms were attributed to the menopause, and have continued, increasing only slightly in severity until three weeks ago. Three weeks ago she began to have pain in her back. Two days ago a portion of the cervix was amputated and the base cauterized. There are no rectal or bladder symptoms, and she has lost no flesh or strength, and aside from the pain in the back she feels well.

Treatment.

Dec. 5, 1916: 9 tubes; 270 m.c.; 1 mm. rubber-covered platinum; in cavity of ulcer; 2 hrs.

This treatment produced practically no effect on the growth.

Jan. 29, 1917: Died with hemorrhages from uterus.

In the very advanced cases of uterine cancer when the disease has extensively invaded the broad ligaments or the rectovaginal septum or the anterior vaginal wall, with the present methods

of application, little can be hoped for by any local methods, except temporarily cleaning up the ulceration in the vagina. Persistent attempts will only cause fistulæ, and render the patient more uncomfortable, without really reaching the whole disease. The only thinkable method of attack in the more advanced cases is the distant application, thickly wrapped, placed within the vagina, and a similar attack from the outside on the peritoneal surface. The advantage of these distant applications consists in the fact that they do not destroy the normal tissues, and yet penetrate with a fairly uniform dosage for great distances.

Two patients with uterine fibroids have been treated with radium alone. The results were good. One of these patients was treated by a combined external and internal application, the other by two external applications alone. In both patients the tumors completely disappeared; the bleeding ceased. In the second patient without even an erythema of the skin the uterus returned to apparently its normal condition.

Carcinoma of Breast

The majority of patients with recurrent carcinoma of the breast are unfavorable for treatment by radium. The different varieties of cancer of the breast yield to radium rather readily, and this is as true of the recurrent as of the primary growths. As a rule, however, the recurrent growths are already so widespread that a temporary objective improvement is all that can be hoped for. This result can be accomplished with less cost and labor with *x*-rays, and also with less effort to the patient, so that the majority of these tumors are better treated by the *x*-rays.

As regards the primary tumors of the breast, we have been unwilling to assume the responsibility of treating these with radium unless they are inoperable, or the patient has refused operation.

Thus far there has been only one patient with a primary operable growth of the breast treated by radium. This patient refused operation. The summary of her clinical record is as follows:

Case M. D. Hosp. No. 22489. Female, 70 years old.

Primary cancer of the breast. One excessive treatment, caus-

ing the patient considerable suffering, but resulting in an apparent cure.

Condition on Admission, October 2, 1915.—An ulcer 1½ inches in diameter with a hard base and underlying induration, 1 inch in thickness is present upon the surface of the right breast, to the outer side and above the nipple. The nipple is retracted and the adjacent skin is retracted and adherent. The growth appears to be slightly adherent to the deeper tissues. No glands are palpable in the axilla.

History.—The lesion first appeared two years ago as a small ulcer which has gradually increased to the present size. She had previously received a blow upon the breast from a broom handle. Her general health has always been good. The patient is rather short and well supplied with subcutaneous fat. The opposite breast is soft and large.

Treatment.

Oct. 2, 1915: 5 plaques; 250 m.c.; 1 mm. silver covered with rubber; directly on surface of growth; 12 hrs.

Nov. 3, 1915: Skin ulcerated over an area 2 by 3 inches. Much pain in the ulcer.

Apr. 11, 1916: Slough has separated and ulcer practically covered with epithelium. No induration. Small gland size of a marble in the axilla.

July 12, 1916: No evidence of disease present. Gland unchanged.

Sept. 20, 1916: No recurrence. Gland unchanged, unquestionably inflammatory. Patient entirely comfortable.

Feb. 13, 1917: No change in condition.

Eight other patients, all, with one exception, with advanced recurrent cancer of the breast, have been much improved.

The following summary of the clinical record of two of these patients illustrates the character of these improvements:

Case C. M. Hosp. Nos. 23574 and 23259. Female, 36 years old.

Large cancer of the breast and in the axillary glands. Both lesions retrogressed completely by three or four strong surface applications. Death later from visceral metastases.

Condition on Admission, November 15, 1915.—An ulcerated

flattened mass 2½ inches in diameter involves the skin above and to the right of the right nipple. An indurated extension from this mass (not ulcerated) extends internally to the nipple beneath the skin, inward and downward for a distance of 3 inches. The nipple is retracted. A couple of cutaneous nodules ¼ inch in diameter are present 1 inch below the main mass and one cutaneous nodule ½ inch above it. There are two lymphatic nodes 1 cm. in diameter in the axilla. The general nutrition of the patient is poor, and the breasts are flabby and small, containing no fat. The legs are edematous, and the abdomen contains much fluid. The urine shows the changes of a rather severe subacute nephritis.

Mx: Carcinoma.

History.—A small nodule appeared in the right breast 12 years ago, and the present condition gradually developed since that time. She has had no treatment. For the past 2 years there has been considerable pain in the breast. The nephritis is of 2 years' standing, and contra-indicates any operation.

Treatment.

Nov. 15, 1915: 3 plaques; 250 m.c.; 1 mm. silver, 2 mm. rubber; directly; 12 hrs.

Dec. 13, 1915: 1 plaque; 100 m.c.; 3 mm. lead, 1 inch of gauze; to cutaneous nodules; 24 hrs.

Dec. 21, 1915: 2 plaques; 200 m.c.; 1 cm. lead; to cutaneous nodules; 6 hrs.

Feb. 23, 1916: 2 plaques; 300 m.c.; 3 mm. lead; to glands in axilla; 22 hrs.

The local treatment caused a slight not uncomfortable desquamation of the superficial epithelium around the ulcer, and some slight burning pain.

May 1, 1916: There is a complete retrogression of all local signs of the disease.

June 12, 1916: Returned to the hospital with marked ascites and a few new cutaneous nodules at some distance from the site of the original lesion; died Aug. 17, 1916.

Autopsy.—An autopsy performed showed carcinomatous infiltration of the right costal and visceral pleura. No metastases in the lungs. The bronchial glands were carcinomatous. Numerous carcinomatous nodules in the liver. Advanced interstitial nephritis.

Case E. H. Hosp. No. 23398. Female, 48 years old.

Condition on Admission, July 5, 1916.—The usual cicatrix following amputation of the breast crosses the left chest to the axilla. Within the cicatrix and surrounding it within a distance of 2 to 3 inches from the cicatrix are half a dozen cutaneous nodules, only one of which is ulcerated. The largest nodule is one inch in diameter.

Mx: Adenocarcinoma with extensive involvement of the lymph nodes.

History.—The amputation of the breast was performed by Dr. Lucius Hotchkiss 8 years ago. The patient first noticed a tumor beginning to grow in the breast 2 years previously. She has always been in good health aside from the present trouble. She has no cough and is in excellent health at the present time. She is well nourished and moderately fat.

Treatment.

July 5, 1916: 12 plaques; 600 m.c.; 3 mm. lead, 2 cm. wood; directly over nodules; 7 hrs.

Aug. 30, 1916: A very considerable retrogression of all nodules. At present only three nodules palpable.

Sept. 20, 1916: 4 plaques; 300 m.c.; 3 mm. lead, 2 cm. wood; 12 hrs.

3 plaques; 150 m.c.; 2 mm. lead, ¼ inch gauze; 12 hrs.

Jan. 22, 1917: Only two minute cutaneous nodules remaining, each about ¼ inch in diameter and each showing marked retrogressive flattening. A very small enlarged supraclavicular lymphatic can be felt.

Jan. 22, 1917: 4 plaques; 240 m.c.; 2 mm. lead, 2 cm. wood; to supraclavicular glands; 6 hrs.

1 plaque; 100 m.c.; 2 mm. lead, few layers gauze; directly to each cutaneous nodule; 6 hrs.

Mar. 15, 1917: The supraclavicular gland has decreased in size. Only one nodule remains on the chest. It is very small and flattened.

Three patients with cancer of the breast have been treated prophylactically immediately after operation. In the case of two of these patients the growth removed was an early one Both these cases are recent ones, and both are now well. The

third patient was operated upon for a recurrence in the sternum. She died a few months after treatment, of visceral metastases, without recurrence in the region treated.

Nine patients with cancer of the breast have been very slightly or not at all improved. The clinical record of one of these patients is as follows:

Case C. R. Hosp. No. 23860. Female, 47 years old.

Recurrent cancer of the breast of large size. Comparatively little effect from a single radium treatment. The skin was unusually sensitive from the previous *x*-ray treatment.

Condition on Admission, July 31, 1916.—A discoid swelling below the left clavicle with a broad base, 4 inches in diameter, losing itself above in the supraclavicular space. The swelling is not much raised. The patient's arm is swollen and edematous, and she has considerable pain in the arm.

History.—The left breast was amputated on July 31, 1915, for a tumor of the breast noticed 4 weeks previously. Three months ago the present recurrence appeared as a small lump below the clavicle, which has gradually increased to the present size. She has had a course of *x*-ray treatment. The patient's mother, who was operated upon for cancer of the right breast twenty years ago, is still alive.

Treatment.

July 3, 1916: 15 plaques; 750 m.c.; 3 mm. lead, 2 cm. wood; directly to mass; 12 hrs.

This treatment produced in four weeks a desquamation of the superficial epithelium, without special discomfort, and small diminution in the size of the tumor.

Oct. 4, 1916: Little change in the size of the tumor.

Jan. 2, 1917: Died.

Nine patients were not essentially improved. The failure to secure improvement was entirely due to the very advanced condition.

In the case of cancer of the breast a different problem presents itself than in the case of cancer of most mucous membranes. The operative results of cancer of the breast have been good when a proper operation has been performed upon an early tumor. Moreover, the operation for cancer of the breast

is not a dangerous one, nor is it accompanied by a serious deformity.

In the case of many cancers of the breast the tumor is deeply situated, and the breast is fat and very mobile. These conditions render its treatment by radium somewhat difficult. The site of the regional lymphatics is some distance from the breast and somewhat inaccessible to radium therapy. Further, many cancers of the breast, those, for instance, having a relation to a chronic mastitis, may be diffuse, and the suspected tissue involved of considerable volume. All these considerations may render many cases of primary carcinoma of the breast less favorable for treatment by radium than by operation.

On the other hand there are many cases of cancer of the breast which are peculiarly suitable for radium treatment. These are the well localized tumors of the breast of small size, occurring in breasts not possessing an excess of adipose tissue. Many of these tumors are scirrhous cancers and are slow growing, others are well isolated only because they are discovered early. They form small nodules, which are discrete and well set apart from the rest of the breast. They may, therefore, be satisfactorily covered with a radium applicator, and offer favorable conditions for the successful radium treatment. Its success will depend upon how far the disease has invaded the lymphatics, which after all is the only factor which will also determine the success of surgery in cancer of the breast.

If it proves justifiable to use radium in early cancer of the breast it will be in this class, and the probability of its success is sufficient to justify its use in this form of cancer of the breast at the present time, when for other reasons operation is not favored. The use of radium in any cancers of the breast should not be discouraged simply because operation in the vast majority of cases is the safer procedure.

There are two other indications for the use of radium in cancer of the breast. The first concerns those patients who absolutely refuse consultation when they become aware of a lesion in the breast, from the simple fear of operation, and their sharing of the general popular belief of the failure of surgery in malignant disease. It should become known to physicians that radium offers a definite prospect of cure in certain forms of cancer of the breast.

The second indication concerns the many cases of cancer of the breast upon the border line of operability. There exists in the minds of many surgeons the belief that an operative removal offers such patients a shorter length of life than some nonoperative method of dealing with their disease. Halstead (*Annals of Surgery,* 1907, XLVI, 1), for instance, states he "is indubitably convinced that the local and regionary recurrences after incomplete operations, which come as a rule with amazing rapidity when the knife has been used, are, to say the least, relatively late in making their appearance when chemical or actual cauterization has been employed." On several occasions he has operated upon cancers which had been vigorously and repeatedly treated with caustics, and has noted the comparatively admirable condition, the freedom from cancer permeation of the surrounding tissues and of the axilla; whereas after incomplete operations with the knife the local manifestations of recurrence were almost invariably deplorable, and the prognosis, of course, invariably hopeless.

Unquestionably we may regard radium or the *x*-rays as possessing the same advantage in dealing border line cases; and whenever the possibility of doing a complete operation is doubtful, the results thus far obtained by radium demand that it should be carefully considered as an alternative treatment.

I would not recommend radium as a primary resort in mammary cancer.

Parotid Tumors

Many tumors of the parotid gland show a special susceptibility to radium. This has been illustrated by three tumors which we have treated. Two of these tumors have completely retrogressed, and the third has practically done so.

Their clinical records are as follows:

Case M. O'C. Hosp. No. 21103. Female, (?) years old. Adenocystic epithelioma, probably originating in the parotid gland. Apparently cured by ten mild radium treatments followed by *x*-ray treatment.

Condition on Admission, February 17, 1914.—Behind the lobe and lower half of the pinna of the right ear is a rounded

eminence produced by a tumor of the parotid gland, to which the skin was adherent, and which itself was adherent to the deeper structures so that it was immovably fixed to the mastoid process. The whole mass formed a growth of 1½ inches in diameter.

Mx: Adenoid cystic epithelioma; no involved lymph nodes.

History.—The growth was first noticed 7 years ago. It gradually increased in size. One year ago the patient suddenly developed a paralysis of the right seventh cranial nerve. An incision was made under the mass and a small piece removed for microscopic section.

Treatment.

Feb. 17, 1914; 1 tube; 5 m.c.; .5 mm. aluminum; within the incision; 4 hrs.

Feb. 24, 1914; 1 tube; 5 m.c.; .5 mm. aluminum; within the incision; 4 hrs.

Mar. 3, 1914: 1 tube; 5 m.c.; .5 mm. aluminum; within the incision; 4 hrs.

Mar. 10, 1914; 1 tube; 5 m.c.; .5 mm. aluminum; within the incision; 4 hrs.

Mar. 17, 1914: 1 tube; 5 m.c.; .5 mm. aluminum; within the incision; 4 hrs.

Apr. 7, 1914: 1 tube; 8.7 m.c.; 5 mm. aluminum; within the incision; 4 hrs.

Apr. 15, 1914: 1 tube; 8.7 m.c.; .5 mm. aluminum; within the incision; 4 hrs.

Apr. 23, 1914: 1 tube; 8.7 m.c.; .5 mm. aluminum; within the incision; 4 hrs.

May 20, 1914; 1 tube; 8.7 m.c.; .5 mm. aluminum; within the incision; 4 hrs.

May 27, 1914; 1 tube; 8.7 m.c.; .5 mm. aluminum; within the incision; 4 hrs.

The treatment was followed by complete retrogression of the growth, with the exception of the thickening in the pinna and tragus, which was reduced by subsequent treatment by *x*-ray.

Case L. W. Hosp. No. 22274. Male, 50 years old.

Carcinoma of the parotid. Apparently cured by two applications.

Condition on Admission, July 6, 1915.—A large ulcerated globular mass, the size of an orange, protrudes from behind the right ear. In front of the ear there is a discoid, smooth swelling about 2 inches across its base. There is a loss of function in the right facial nerve.

Mx: Alveolar carcinoma in the center of a large mass of granulation tissue.

History.—Sixteen years ago a tumor was removed from the region behind the right ear, in Warsaw. During the succeeding four years, he was operated upon again 4 times for 4 recurrences. Following the first of these 4 operations the function of the seventh nerve was lost. The patient was then well for 5 years. The tumor then again recurred and the patient was operated upon at the Manhattan Eye and Ear Hospital for a recurrence a few months ago. The patient is in good health and well nourished.

Treatment.

July 20, 1915: several plaques; 150 m.c.; 1 mm. rubber-covered silver; to tumor; 10 hrs.

Dec. 25, 1915: 3 plaques; 130 m.c.; 1 cm. lead covered with rubber; to tumor in front of ear; 8 hrs.

The mass behind the ear practically disappeared and the tumor in front is about half the original size.

Feb. 13, 1917: Free from evidence of disease.

Case A. M. Hosp. No. 23176. Male, 49 years old.

Mixed tumor of the parotid. A very considerable objective retrogression following four external treatments.

Condition on Admission, May 7, 1916.—In the position of left parotid gland there is a nodular tumor, forming a rounded eminence 2½ inches in diameter and ½ inch high. At the lower and anterior corner of the main mass is a nodule about the size of a walnut, which is quite discrete. Crossing the tumor is a scar.

History.—The tumor was first noticed in Sept., 1915. In October an attempt was made to remove it by operation. The patient denies syphilis, and is not alcoholic.

Treatment.

May 7, 1916: 11 plaques; 825 m.c.; 3 mm. lead and rubber; to tumor; 8 hrs.

June 9, 1916: 2 plaques; 200 m.c.; 3 mm. lead; to two resistant places; 6 hrs.

July 8, 1916: 7 plaques; 350 m.c.; 3 mm. lead, 1 cm. gauze; to the gland; 6 hrs.

Aug. 14, 1916: 12 plaques; 840 m.c.; 3 mm. lead, 2 cm. wood; to the gland; 12 hrs.

To Dec. 1, 1916, there has been a continuous diminution in the size of the tumor.

Nov. 29, 1916: Eight days ago first noticed a paresis of the left facial nerve. Small lymphatic nodule in neck, about ½ inch in diameter.

Jan. 16, 1917: Continued diminution in size of the tumor. Face is still paralyzed.

Other tumors of the parotid contain considerable cartilage and form hard growths. It is not to be expected that these less cellular growths would change rapidly in size under the influence of radium.

We have treated two such patients. One of these patients, because of the size of the growth, was not improved. The result in the second patient was fairly satisfactory. While before treatment his tumor had grown fairly rapidly, after treatment it did not change in size. Apparently the treatment destroyed its actively proliferating elements, rendering the growth stationary. His clinical record is as follows:

Case D. M. Hosp. No. 23289. Male, 49 years old.

Mixed tumor of the parotid of hard consistence, probably containing considerable cartilage. Entirely checked in its growth by one treatment.

Condition on Admission, June 1, 1916.—In front and a little below the tragus of the right ear in the region of the parotid gland there is a rounded tumor, 2 inches in diameter at its base and about ½ inch high. The surface is nodular, and the consistency of the tumor is hard.

History.—The tumor was first noticed six months ago. It formed then a small nodule in the parotid gland. Two years before he had sustained an injury to this region by a fall against a curbstone.

Treatment.

June 6, 1916: 3 plaques; 255 m.c.; 3 mm. lead, 1 cm. gauze; over surface of tumor; 8 hrs.

Aug. 31, 1916: The skin over the tumor has passed through a period of superficial peeling, due to the radium dermatitis, and is now healed. The tumor seems a trifle smaller.

Dec. 6, 1916: Tumor, if anything, seems slightly smaller. Its progressive growth has certainly been checked.

Cancer of the Cervical Lymph Nodes

A number of patients have been grouped as cancer of the cervical lymph nodes which include at least one endothelioma and other malignant growths of uncertain character. A number of them are carcinomata, some of them primary, but others unquestionably secondary to a primary growth of unknown location.

It not infrequently happens that a small primary growth of the pyriform sinus gives rise to a large metastatic tumor in the neck, and if the patient dies and no autopsy is performed, the primary growth will altogether escape detection. This is particularly true when the size of the tumor in the neck renders a complete laryngeal or esophageal examination impossible. Other growths of the neck are primary embryonal epitheliomata.

The patient with endothelioma of the cervical lymph nodes has given an ideal retrogression. His clinical record is as follows:

Case S. Y. Hosp. No. 23213. Male, 28 years old.

Endothelioma of the cervical lymph nodes. Apparent complete retrogression produced by a single treatment.

Condition on Admission, May 16, 1916.—On the left side of the neck there is a large discoid swelling, involving the whole side of the neck from the lower jaw to the clavicle. It is nodular on its surface and hard in consistency. There is no lesion in the throat or larynx.

Mx: Endothelioma of markedly alveolar type.

History.—The patient has been operated upon twice for the

removal of a glandular tumor of this side of the neck; the first time by Dr. Pool of the New York Hospital, 1½ years ago; and again 2 months ago by Dr. Moorhead. The present tumor is a recurrence, following these operations. His previous health, other than the present trouble, has been good.

Treatment.

May 16, 1916: 8 plaques; 800 m.c.; 3 mm. lead, ½ cm. gauze; to neck; 8 hrs.

July 5, 1916: Tumor smaller, superficial radium ulceration.

Aug. 16, 1916: The disease has apparently completely retrogressed. Skin scaly and red.

Dec., 1916: No sign of disease present.

Mar. 15, 1917: Letter received stating that he is well.

In none of the other patients with carcinoma of the cervical lymph nodes, with the possible exception of one other patient, who is still under treatment, has anything more than a temporary reduction in size of the tumor followed the treatment.

As has been emphasized in discussing cancer of the inside of the mouth, epithelioma of the cervical lymph nodes has only been partially affected by external applications.

Three patients are still under treatment. One patient died of an intercurrent illness, improved as regards the tumor of the neck. Six patients have been unimproved.

The clinical record of the patient showing the marked improvement is as follows: We are disposed to attribute the great improvement to the very heavy treatment which he received.

Case J. H. Hosp. No. 23858. Male, 64 years old.

Condition on Admission, October 31, 1916.—On the right side of the neck, beneath the upper two-thirds of the sternomastoid muscle, there is a rounded swelling which measures 3 inches by 2½ inches across its surface. The consistency is hard and the surface is nodular. Along the anterior border of the swelling is a cicatrix. The larynx, pharynx and nose are free from objective evidence of disease.

Mx: Plexiform epidermoid carcinoma.

History.—The swelling in the neck was first noticed in Aug., 1916, and progressively enlarged until Sept. 11, 1916, when the anterior portion of the tumor was removed.

Treatment.

Oct. 31, 1916: 12 plaques; 900 m.c.; 2½ mm. lead, 2 cm. distant; to right side of neck; 18 hrs.

Jan. 15, 1917: 9 plaques; 765 m.c.; 2½ mm. lead, 4 cm. distant; to right side of neck; 10 hrs.

Following this treatment there were some superficial ulceration and a rapid retrogression of the tumor.

Feb. 13, 1917: Only a small, somewhat indefinite nodule remains in the neck.

Teratoid Carcinoma of Testis

From the standpoint of the therapeutic results, no more important tumor has been treated by us than carcinoma of the testis. These tumors, often incorrectly called sarcomata, are really teratomata, with carcinomatous overgrowth of their epithelial elements.

They have shown the most remarkable susceptibility to radioactivity of any tumor with which we are acquainted. Whether this susceptibility depends alone upon a specific susceptibility of this particular tumor tissue, or as is far more probable, upon the fact that its cells are undergoing active cell division, makes little difference: the tumor, even when of huge size, is often rapidly destroyed and absorbed. The question of the ultimate result cannot be determined for some years.

Five of these tumors, including one similar tumor of the ovary in a little girl, have been treated and in each instance a single application has produced, within about one or two weeks, a complete clinical retrogression of tumor masses almost the size of an adult head. Two others, received in a critical condition, were treated without success.

This result is superior to that which has been obtained by the use of the *x*-rays, at least in any case with which we are familiar; and it opens up an entirely new chapter in the treatment of this disease.

All of these patients are still well and free from recurrence, with the exception of one, who is now under treatment for a partial return of the growth. The clinical records of these patients are as follows:

Case S. R. Hosp. No. 23134. Female, 10 years old.

Advanced carcinoma (teratoma) of the ovary in a child. Complete retrogression from one treatment.

Condition on Admission, April 30, 1916.—The entire pelvis and lower abdomen is filled with a hard nodular mass the size of a child's head.

History.—One year ago the patient began to feel pain in the abdomen. Three months ago she experienced difficulty in micturition. An examination of the abdomen revealed the presence of a large tumor. It was operated upon in Panama, Mar. 1, 1916. At this operation a large mass was found in the abdomen, which grew apparently from the os innominata, but the size of the tumor was so large that its exact connection was not ascertained, and the operation resolved itself into a mere exploratory incision. From its gross appearances it was thought to be an osteosarcoma, but from the results of treatment it is unquestionably a teratoma of the ovary.

Treatment.

Apr. 30, 1916: 4 plaques; 250 m.c.; 3 mm. lead and rubber; to each side of abdomen; 6 hrs.

Following this treatment the tumor entirely disappeared within a few weeks' time.

Jan. 20, 1917: No growth palpable in abdomen. General health excellent.

Mar. 15, 1917: Condition unchanged.

Case J. R. Hosp. No. 23133. Male, 42 years old.

Metastatic carcinoma of the testis. Apparent complete retrogression from three strong treatments, two of which were applied in different places.

Condition on Admission, October 1, 1916.—The left hypochondrium contains a mass which is hard and nodular, and reaches from just beneath the costal margin to the umbilicus. The right iliac region contains a second nodular tumor about the size of a fist. Its upper limit is a little above the anterior superior spine of the ilium. The right testicle has been removed.

Mx: Teratoma of testis.

History.—In July, 1913, it was noticed that the right testicle was increased in size and the patient felt some discomfort in it.

Within 8 weeks the testicle reached the size of a fist, and remained this size for two years. In Oct., 1915, the discomfort increased and the patient discovered that the glands in the groin were enlarged. The Wassermann reaction was reported in Nov., 1913. Salvarsan was administered without effect at St. Vincent's in Oct., 1915. The right testicle and glands in the groin were removed because of the pain. In Mar., 1916, he began to have pain in the abdomen, and discovered the presence of abdominal masses. He contracted syphilis at 28 years of age. He never injured the testicle.

Treatment.

Oct. 1, 1916: 12 plaques; 660 m.c.; 3 mm. lead, 2 cm. wood; to hypochondrium; 12 hrs.

12 plaques; 660 m.c.; 3 mm. lead, 2 cm. wood; to right iliac region; 12 hrs.

Following this treatment, within one week there was practically a complete retrogression of all palpable masses.

Nov. 14, 1916: Original masses in epigastrium and inguinal regions have entirely disappeared. The mass in the groin is still present.

Nov. 14, 1916: 12 plaques; 836 m.c.; 3 mm. lead, 2 cm. wood; to groin; 12 hrs.

Jan. 17, 1917: No tumor palpable. The general condition is excellent.

Case C. S. Hosp. No. 23836. Male, 31 years old.

Advanced teratoma of the testis. Much improvement during a series of abdominal treatments.

Condition on Admission, October 23, 1916.—Filling the epigastrium is a hard, firmly fixed tumor, extending from beneath the costal margin to 1 inch below the umbilicus, and to the mammary lines on both sides. The patient is in considerable pain, persistent nausea and vomiting, and the abdominal wall is tense and rigid. In order to relieve his discomfort he occupies a bent-forward position, with the knees drawn up most of the time. He had lost much weight.

History.—On May 6, 1915, he received an injury to the right testicle. Both testicles became swollen and painful. The swelling of the right testicle increased, and in July it was removed. In Feb., 1916, he began to feel pain in the lower

abdomen and lumbar region. The pain has gradually increased to the present time.

Treatment.

Oct. 29, 1916: 14 plaques; 630 m.c.; 2 mm. lead, 2 cm. distant; over mass; 12 hrs.

Nov. 4, 1916: The tumor has practically disappeared.

Nov. 16, 1916: Slight superficial radium ulceration on the surface of the abdomen.

Dec. 5, 1916: 12 plaques; 480 m.c.; 2½ mm. lead, 3 cm. distant; over the sternum; 16 hrs.

Dec. 14, 1916: No palpable masses in the abdomen.

Dec. 16, 1916: 12 plaques; 516 m.c.; 2½ mm. lead, 3 mm. distant; over the sternum; 16 hrs.

Together with the radium treatment the patient received between Oct. 29 and Dec. 16, 1916, 35 injections of the mixed toxins. Further administration of the toxins was discontinued at the patient's request.

Jan. 8, 1917: The mass has reappeared high up under the epigastrium.

Jan. 8, 1917: 12 plaques; 600 m.c.; 2½ mm. lead, 3 cm. distant; in 2 places on abdomen; 10 hrs. each.

Jan. 27, 1917: A new mass can be palpated lower down in the abdomen.

Jan. 27, 1917: 12 plaques; 960 m.c.; 2½ mm. lead, 6 cm. distant; on 2 areas of abdomen; 5 hrs. in each place.

Feb. 12, 1917: A hard mass the size of an orange can be felt high up in the epigastric region.

Feb. 12, 1917: 12 plaques; 804 m.c.; 2½ mm. lead, 3 cm. distant; to right side of lumbar region; 12 hrs.

Following this treatment there was a temporary period of nausea and abdominal discomfort, after which he never felt better, and the mass in the epigastrium became smaller.

Feb. 25, 1917: 12 plaques; 939 m.c.; 2½ mm. lead, 3 cm. distant; to back and abdomen; 12 hrs.

Improvement continued until Mar. 19, when he again began to vomit; and when examined on Mar. 24, 1917, the mass seemed somewhat larger.

Case H. McG. Hosp. No. 23840. Male, 36 years old.

Apparently complete disappearance of a large teratoma of

the testis, recurrent in the abdomen, after one treatment.

Condition on Admission, Oct. 30, 1916.—The right lumbar region and lower portion of the right side of the epigastric and right side of the hypochondrium contains a mass which reaches from two finger breadths below the juncture of the costal cartilages and the ribs to about 2 inches below the umbilicus, and from 2 inches on the left of the middle line to 3 inches to the right of the middle line of the abdomen. Its total diameter is, therefore, about 5 inches, as measured on the surface of the abdomen. The consistency is hard and uneven. The right testicle measures 5 by 4 inches in diameter.

Mx: Teratoid carcinoma.

History.—The enlargement of the testicle first appeared two years ago. With the exception of a short period 13 months ago when the testicle was strapped, it progressively increased in size. He first became aware of the mass in the abdomen 3 months ago. He attributes his trouble to an injury sustained 2 years ago. One year and a half ago his right testicle was struck by a log of wood. Following this injury the organ increased in size rapidly.

Treatment.

Oct. 31, 1916: 12 plaques; 840 m.c.; 2½ mm. lead, 2 cm. distant; to two areas on abdomen; 12 hrs.

Dec. 23, 1916: No mass is palpable in the abdomen. It seemed to have disappeared in one week. Two weeks after the application the right testicle was removed.

Dec. 23, 1916: 12 plaques; 960 m.c.; 2½ mm. lead, 3 cm. distant; over the sternum; 8 hrs.

Mar. 21, 1917: No evidence of disease present.

In addition to the above cases two patients received after Jan. 1, 1917, in the last stages of cachexia from abdominal recurrences, and with edema of limbs from pressure on the great vessels, were treated by radium without successful result. Each died within one or two weeks after admission to the hospital, and autopsy disclosed in each very extensive metastases in abdominal nodes compressing the aorta and great veins, and in one large pulmonary tumor. In the first of these cases the tumor masses were very dense and fibrous and would probably not have receded under radium. In the other the abdominal

tumors had undergone massive necrosis, apparently within the week following the treatment, while the large pulmonary tumors were intact.

Cancer of the Skin

Cancer of the skin has long enjoyed the reputation of being the field in which radium is perhaps of greatest service. Only, however, in its earliest stages is it easily cured by radium. The resistance of cancer of the skin to radio-activity when the disease has been allowed to gain headway is so marked that it shows that there is no special susceptibility of this disease to radium. Clinically the disease is characterized by a slow growth and failure to form metastases.

These characters mean that it is formed of cells whose nuclei are not in an active state of division. Theoretically, therefore, there is little reason to believe that cancer of the skin should show any special susceptibility to radium.

There is only one reason why cancer of the skin has earned the reputation of deserving, before all other forms of cancer, treatment by radium as the method of choice. It is because it is most frequently discovered in the earliest stages. It is superficially situated, and usually on that portion of the skin where it is most quickly noticed, and where its presence is most objectionable, namely, on the face. Treatment, therefore, has more frequently been applied to cancer of the skin when the disease is less than a few millimeters in diameter than is the case with any other form of cancer. Intimacy of contact with the radium applicator is perfect. Only normal cells could escape the destructive influence of treatment under these conditions.

Allow, however, cutaneous epithelioma, whether of the basilar, which certainly yields more readily, or epidermoid type, to infiltrate deeper than the corium, or, after several years of only partially successful treatment by operation, *x*-rays or caustics, to infiltrate through the lymphatic spaces the surrounding structures, and epithelioma of the skin is one of the most trying forms of cancer to heal by radium. Yet radium is often the only therapeutic agent which can hope to cope with it, not excluding the *x*-rays. While it can cope with some of these advanced lesions, its successful use in them is by no means easy and in many patients fails.

The majority of the primary cutaneous epitheliomas which have not been interfered with are best treated by direct application. The ½ inch square ½ mm. flat silver applicator, containing 50 m.c., left in place upon the lesion for 2 hours, usually accomplishes a cure of the lesion in one application. For deeper lesions the same dose in 2 mm. of lead for 8 hours is invariably successful. Great care must be used to cover the lesion completely; and for lesions larger than 1 cm. in diameter larger squares; or several placed together must be used.

Another class of skin lesions are those which still appear small, but which have previously been treated in various ways. The majority of these have invaded the deeper tissues. They often form immovable ulcers at the inner canthus of the eye, because it is particularly in this situation that compromising operations or caustics have been used. In this situation their small superficial size is no indication of the depth of infiltration and length of some of the extensions of the disease. In the neighborhood of the eye it is desirable to manage these ulcers by the use of many tubes inserted in every corner, so as to cover the whole ulcer, and in this manner by the shorter, more direct exposure, to avoid damage to the retina. If, however, the process is uncontrolled by this method it may be necessary to sacrifice the eye and treat the whole region by a longer and more distant application. When these deeper lesions are not in the proximity of the eye, and the disease is accessible, the more distant applications will sometimes accomplish what nothing else will.

Some care must be used in the use of very strong distant applications over the cranium. Following such applications we have seen symptoms develop which made us fear that a radium injury to the cortex itself had been produced.

A good deal of care must be used, however, in the management of patients previously treated with the *x*-rays. The normal tissues of these patients have been invariably so injured by the *x*-rays that they will not stand strong radium exposures without the production of burns which would not be produced by the same exposures of normal tissues. In many of these patients reliance can only be placed upon the use of the multiple tubes. This rule particularly applies to patients in whom the disease has invaded the orbit or the nasal cavity. In the case of

these lesions only a patient following up of the disease by repeated direct application will accomplish a cure. The greatest care must be exercised to avoid a burn. When several tubes containing 30 to 40 m.c. each are used, two hour applications are sufficient. Often the patients must be seen at weekly intervals, and the course of treatment extended over a year or longer.

The fact that the basal cell form of cutaneous epithelioma, to which the majority of this variety belong, do not form metastases makes it possible to follow this disease to its ultimate limits. A persistent effort at the expense of much patience will succeed in many of these advanced forms of cutaneous epitheliomas, and the end result, although accompanied with much deformity, is so deeply appreciated by many of these patients that it is surely worth while.

Ninety-five cutaneous epitheliomas have been treated. Sixty-seven of these have undergone a complete clinical retrogression. The majority of these have been cured by one treatment.

The following clinical records are illustrations of this class of cases. The results are ideal in the early lesions, previously untampered with by inefficient *x*-ray therapy, incomplete operation, diathermy, electric needles, or caustics. The record of the fifth of the following cases is an illustration of a complete retrogression in a very advanced lesion. Yet the lesions in the first and sixth cases were of no small size when they came for treatment.

Case. M. Hosp. No. 21747. Male, 68 years old.

Fairly large epithelioma of the skin of the nose. Treated with a number of mild applications, and finally with a stronger dose. Complete clinical retrogression, followed by death from apoplexy a few months later.

Condition on Admission, November 10, 1914.—An elevated but flattened ulcer about the size of a half dollar is situated upon the middle of the front of the nose. The surface is raw and formed of neoplastic tissue throughout. The edges are rolled out and hard and the whole growth typical.

Mx: Epithelioma.

History.—Of late years the patient has had rather numerous warts appear from time to time on the skin. The present lesion

has developed from one of these warts which appeared on the nose 2 years ago, and which his physician had attempted to remove with applications of acid. A second similar attempt was made in July, 1914.

Treatment.

Nov. 10, 1914: 1 plaque; 15 m.c.; 1 mm. lead and rubber; to nose; 10 hrs.

Dec. 12, 1914: 1 plaque; 25 m.c.; 1 mm. lead and rubber; to nose; 4½ hrs.

Dec. 15, 1914: 1 plaque; 20 m.c.; 1 mm. lead and rubber; to nose; 4 hrs.

Dec. 22, 1914: 1 plaque; 1.7 m.c.; 1 mm. lead and rubber; to nose; 4 hrs.

Dec. 30, 1914: 1 tube; 8.7 m.c.; aluminum and rubber; to nose; 6 hrs.

Dec. 31, 1914: 1 tube; 8.7 m.c.; aluminum and rubber; to nose; 6 hrs.

1 tube; 20 m.c.; 0.6 mm. silver and rubber; to nose 6 hrs.

Jan. 5, 1915: 1 tube; 20 m.c.; 0.6 mm. silver and rubber; to nose; 4 hrs.

Jan. 12, 1915: 1 tube; 23.8 m.c.; 0.6 mm. silver and rubber; to nose; 4 hrs.

Jan. 14, 1915: 1 tube; 22 m.c.; 0.6 mm. silver and rubber; to nose; 4 hrs.

Jan. 19, 1915: 1 tube; 20 m.c.; 0.6 mm. silver and rubber; to nose; 8 hrs.

Following these treatments the growth completely retrogressed, but the patient died of apoplexy a few months later.

Case G. C. Female, 65 years old.

Superficial recurrent epithelioma of the skin, apparently cured by two applications.

Condition on Admission, February 10, 1915.—There is an ulcer with an irregular outline ¾ inch in diameter to the right of the inner canthus of left eye on the lateral surface of the nose. The base is covered in part with cicatricial tissue and is not depressed. The margin is indurated and very slightly raised and typical of superficial cutaneous epithelioma.

History.—About seventeen years ago a small pimple devel-

oped on the side of the nose at the site of the present lesion. It ulcerated from time to time and gradually grew to the size of a quarter of a dollar in the next 13 years. Four years ago it was treated with radium twice each week for 3 months. It was then treated with *x*-rays for 4 months, twice each week. It was then frozen with carbon dioxid snow.

Treatment.

Feb. 10, 1915: 1 plaque; 9 m.c.; 1 mm. silver covered with rubber; directly; 7 hrs.

Feb. 17, 1915: 1 plaque; 20 m.c.; 1 mm. silver covered with rubber; directly; 7 hrs.

Mar. 17, 1915: Lesion entirely healed.

May 9, 1915: No evidence of disease present.

Case E. B. Hosp. No. 22042. Male, 55 years old.

Recurrent epithelioma of the skin. Very heavy dose on surface of tumor, resulted in an apparent cure without untoward effect.

Condition on Admission, June 1, 1915.—A small, hard nodule, the size of a pea, raised above the level of the skin 1/8 inch, is present on the center of the right cheek. It is not ulcerated but typical of epithelioma.

History.—The tumor appeared first twelve years ago as a small papule. It has been twice excised at Johns Hopkins Hospital and recurred after the last operation in March. The patient denies syphilis, and has always been in good health.

Treatment.

May 11, 1915: 1 plaque; 47 m.c.; 1 mm. lead, 2 mm. rubber; directly; 18 hrs.

June 11, 1915: The lesion is replaced by an ulcer 1/2 inch in diameter, covered by healthy granulations.

June 29, 1915: Healed, and apparently cured.

Case D. D. Female, 55 years old.

Superficial epithelioma of the skin, cured by a single application.

Condition on Admission, August 21, 1915.—A superficial ulcer with indurated borders, very narrow and very slightly indurated, is present on the left lateral surface of the nose. The lesion is triangular in shape and flat. The base is not de-

pressed, and is in part cicatricial and in part ulcerated. The whole is typical of epithelioma.

History.—Three years ago the patient was bitten by an insect on the left side of the nose. She scratched the wound from time to time, which persisted as a small red mark. Six months ago the lesion began to increase in size and became covered with a scab. Her health has always been good.

Treatment.

Aug. 21, 1915: 1 plaque; 25 m.c.; 1 mm. silver covered with rubber; directly; 8 hrs.

Sept. 8, 1915: Ulcer clean. Induration gone.

Oct. 13, 1915: Entirely healed.

Feb. 13, 1917: Entirely healed.

Case J. F. Hosp. No. 22942. Male, 54 years old.

Three large multiple epitheliomata of the skin, brought to a state of relatively complete retrogression by two treatments.

Condition on Admission, February 29, 1916.—A quadrilateral shaped ulcer 2 inches in diameter is situated in the right temporal region. Its anterior border involves the outer canthus of the right eye. The margins of the ulcer are raised and indurated. The base is formed of neoplastic tissue. A second ulcer, with characteristic raised and indurated edges, 1 inch in diameter, is present in the groove between the left side of the nose and the cheek. A third, very deep ulcer, with hard base and elevated, hard edges, is situated behind the lobe of the right ear. The base of this ulcer is ¼ inch deep and indurated fissures radiate from it.

Mx: Carcinoma basocellulare.

History.—Twelve years ago a small scab appeared on the right temple. Two years later the lesions on the left cheek and behind the right ear began to grow. All three lesions gradually increased in size to the present time.

Treatment.

Feb. 29, 1916: 4 plaques; 400 m.c.; 3 mm. lead, 2 cm. wood; to temple; 24 hrs.

2 plaques; 200 m.c.; 3 mm. lead, 1 cm. gauze; to ulcer behind the ear; 24 hrs.

2 plaques; 200 m.c.; 3 mm. lead, 1 cm. gauze; to lesion on left cheek; 24 hrs.

May 13, 1916: 2 plaques; 200 m.c.; 3 mm. lead, 1 cm. gauze; to lesion behind left ear; 12 hrs.

3 plaques; 300 m.c.; 3 mm. lead, 1 cm. gauze; to lesion on left cheek; 12 hrs.

Aug. 2, 1916: Lesion on the left cheek healed. The temporal lesion healing. The induration of the lesion behind the right ear diminished 50 per cent.

Mar. 7, 1917: The lesion on the left cheek is still healed, that behind the right ear is also healed. That on the right temple is healed except for a small area near the lower border of the ulcer, where a small sequestrum of the malar bone ½ by ¾ inch in diameter has formed.

Case W. B. Male, 53 years old.

A large epithelioma of the skin of the lower lip. Cured with a single caustic application, applied in a manner to use the tumor as a filter, which prevented any objectionable radium effects.

Condition on Admission, May 1, 1916.—A typical epitheliomatous ulcer on the anterior surface of the chin, elevated ¼ inch, circular in shape, and 1¼ inches in diameter. It does not involve the vermillion border of the lip. There are no enlarged lymphatics.

Mx: Basal cell epithelioma.

History.—In 1893 a mole-like papule appeared on the lip at the site of a cut made by the barber. It was burnt off by a caustic. Five or six years later the lesion recurred and was excised in 1903. It again recurred in 1907. The patient has locomotor ataxia.

Treatment.

May 1, 1916: 2 plaques; 100 m.c.; 3 mm. lead, covered with rubber; directly to ulcer; 24 hrs.

Oct. 10, 1916: No evidence of disease.

It is true that these small cutaneous epitheliomata are such innocent looking lesions, and their cure by a single application of radium seems such a trivial matter that the service rendered to these patients does not at first glance appear of much moment. The benefit, however, conferred upon them can only be realized when they are compared with lesions which

have been allowed to advance beyond the stage of control.

The following case records are illustrations:

Case A. A. Hosp. No. 23255. Male, 71 years old.

Recurrent, well advanced, rodent ulcer of the nose. Treated previously with *x*-rays, and at first with small doses of radium. Gradual extension of the process, which showed very little susceptibility to the influence of subsequent treatments, though the process at present seems to be in a state of fairly complete retrogression.

Condition on Admission, December 31, 1914.—A circular perforation of the right alæ nasi with indurated nodules on the margin and some ulceration of the lateral wall of the nasal cavity. Just how extensive this is could not be determined.

History.—A small papule appeared on the cheek immediately lateral to the alæ nasi five to six years ago. Two attempts were made to excise the lesion, but a recurrence developed in each instance, and gradually developed into the present lesion. He denies syphilis and does not drink. He has never been ill seriously. He has received two *x*-ray treatments.

Treatment.

At first he received treatment with radium once a week for 2 to 3 hours at a time, with 10 to 20 mg., for 2 to 3 months.

Mar. 9, 1915: 1 plaque; 50 m.c.; 0.6 mm. rubber-covered silver; to inner margins; 3 hrs.

May 12, 1915: 1 plaque; 50 m.c.; 0.6 mm. rubber-covered silver; to two places; 3 hrs.

June 8, 1915: 1 plaque; 100 m.c.; 1 mm. rubber-covered silver; to bridge of nose; 6 hrs.

July 12, 1915: 1 tube; 100 m.c.; 1 mm. rubber-covered silver; to bridge of nose and external margin; 7 hrs.

Nov. 22, 1915: 1 tube; 100 m.c.; 0.6 mm. rubber-covered silver; to external margin; 7 hrs.

Dec. 1, 1915: 2 tubes; 200 m.c.; 0.6 mm. rubber-covered silver; within the nasal cavity; 2 hrs.

Jan. 10, 1916: 2 tubes; 200 m.c.; 1 mm. rubber-covered silver; within the nasal cavity; 2 hrs.

Apr. 19, 1916: The whole area appears free from disease, but the original condition has been transformed into a comparatively large cavity by the enlargement of the original opening

to twice its former size and the destruction of the inner wall of the antrum and anterior extremity of the middle and inferior turbinates and a portion of the hard palate, so that the mouth communicates with the nasal cavity. A sequestrum has formed at the inner angle of the orbit and in the septum of the nose.

May 27, 1916: The anterior end of the middle turbinate has again ulcerated.

May 27, 1916: 1 tube; 100 m.c.; 1 mm. rubber-covered platinum; to ulcer; 4 hrs.

Oct. 13, 1916: 3 tubes; 60 m.c.; 1 mm. rubber-covered platinum; to roof of nose; 6 hrs.

1 plaque; 35 m.c.; 2 mm. lead, gauze; to roof of the nasal cavity; 6 hrs.

Nov. 11, 1916: 2 tubes; 68 m.c.; 1 mm. rubber-covered platinum; to nose; 4 hrs.

Dec. 13, 1916: Retrogression appears almost complete. The lesion has never appeared so satisfactory.

Jan. 17, 1917: A large sequestrum has formed at the outer angle of cavity. Still some suspicious looking tissue, partly ulcerated, on the roof of the cavity, and on the prominence of the right alæ nasi.

Jan. 26, 1917: 4 tubes; 1 mm. rubber-covered platinum; to nose; 1 hr.

Mar. 1, 1917: The whole cavity appears healthy with the exception of the inflamed tissues immediately surrounding a small sequestrum beneath the outer angle of the orbit. The sequestrum was loose and was removed.

Case J. M. Hosp. No. 22777. Female, 51 years old.

A recurrent cancer of the skin of the forehead, treated at first without success with moderate doses, and later with still poorer success with a massive dose. Finally operated upon the remnants of the cancer, surrounded by tissues more normal in character; and again treated with more moderate doses.

Condition on Admission, November 9, 1915.—The patient has an ulcerated and partly nodular and cicatricial area surrounding the inner canthus of the left eye. This area is 1 inch in diameter.

Mx: Epidermoid carcinoma.

History.—The lesion has been preceded by the presence of a pimple the size of a pin head upon the inner surface of the root of the nose, which remained without change until 3 to 4 years ago. For the past 3 to 4 years it has been progressively increasing in size. During this period it was first treated with an electric needle, then by *x*-rays for a period of 2 years, without essential improvement.

Treatment.

Nov. 9, 1915: 1 plaque; 100 m.c.; 1 mm. rubber-covered silver; over lesion; 6 hrs.

Dec. 11, 1915: Slight improvement.

Jan. 13, 1916: 1 plaque; 100 m.c.; 3 mm. lead, 1 inch gauze; over lesion; 8 hrs.

Mar. 8, 1916: 1 plaque; 200 m.c.; 3 mm. lead, 1 inch gauze; over lesion; 24 hrs.

Mar. 22, 1916: Considerable retrogression of indurated tissue.

May 22, 1916: A deep slough covers the whole of both eyelids. Notwithstanding the severe treatment last given there has sprung up around the periphery of the necrotic area a circle of freshly growing cancer. The whole infiltrated mass, including the contents of the orbit, was excised. The operation appears to have successfully removed all invaded tissues, except the bone at the inner margin of the orbit.

This region was then given the following treatment:

Jan. 22, 1917: 6 tubes; 132 m.c.; 1 mm. rubber-covered platinum; to inner wall of orbit; 2 hrs.

The histological sections of this case showed actively growing cancer cells in the midst of sloughing normal tissues, and the case affords a most convincing demonstration that the cure of cancer by radium is not accomplished alone by the direct effect of the radium on the cancer tissue, but for its most complete effect in part by a reaction excited in the surrounding normal tissues, so that if these are too greatly impaired by killing doses of radium or changed, as in many recurrent cases after *x*-ray treatment, an essential element in the cure of cancer by radium is necessarily absent.

Mar. 1, 1917: The orbital cavity is covered, except over a small area on its inner wall, with healthy granulations, and seems, as far as can be ascertained, free from disease.

The records of these last two cases are illustrations of the terrible ravages made by cancer of the skin when it has existed long enough to spread beyond the immediate neighborhood of its origin, beyond, in other words, the tissues obviously involved. As we have emphasized above, any method of treatment which falls short of complete destruction of the disease at the start is a most serious matter, because it results in superficial healing but allows the growth of concealed extensions of the tumor, which only become manifest as recurrences after they have endangered important tissues of the face. Moreover, previous ineffectual treatment deprives radium of its best ally, a sound, healthy surrounding bed of normal cells, capable of withstanding the shock of an efficient blow to the cancer cells, and capable of reacting in a manner which certainly permits of a *restitutio ad integram* of which the normal cells once damaged are incapable.

Nevertheless radium is the only means of dealing with such lesions, and if the patient is prepared for a destruction of tissues already doomed, instead of slowly following up the disease as it itself destroys this same invaded tissue, not only may the patient's life be saved, but the period of the treatment immensely shortened. It is necessary at the outset in these cases to recognize that a certain deformity is necessary: the disease must be estimated, as in all forms of cancer, not by its apparent small size following a recurrence, but by its total age.

Of the twenty patients with cancer of the skin who have not been benefited, the same story holds as in cancer of the mucous membranes, all were either advanced or recurrent cases. Seven had been operated upon, six had received some other form of inefficient treatment, and seven were very advanced lesions, which had received no previous treatment.

The following case record is an illustration of this group:

Case P. MacA. Hosp. No. 22840. Male, 65 years old.

Very extensive epithelioma of the spur of the temporal region. Three strong treatments to the whole ulcer produced comparatively little change in the progress of the disease.

Condition on Admission, March 15, 1915.—The left temporal region is the seat of an ulcer 6 inches in diameter, with a hard nodular base and raised rolled-out edges. The ulcer is a

very deep one, and below and posteriorly the edges are prominent and very hard. A deep extension beneath the skin extends downward in the direction of the deep cervical glands from the posterior corner of the lower margin of the ulcer.

Mx: Epidermoid carcinoma.

History.—The patient had a chancre 15 years ago. The present growth first appeared a year ago as a small pimple on the left temporal region. It has gradually grown to the present size, notwithstanding some four electrical treatments and *x*-ray treatment, from Mar. 15, 1915, to Oct. 14, 1915.

Treatment.

Nov. 6, 1915: 1 plaque; 50 m.c.; 1 mm. rubber-covered silver; applied around the edge; 6 hrs. in several places.

4 plaques; 250 m.c.; 1 mm. rubber-covered silver; to base; 6 hrs.

Dec. 7, 1915: 4 plaques; 450 m.c.; 1 mm. silver, 1 cm. gauze; (?); 6 hrs.

Dec. 21, 1915: 4 plaques; 200 m.c.; 1 cm. lead; (?); 8 hrs.

The growth was practically uninfluenced. The patient left the hospital Feb. 4, 1916, and died shortly afterward.

Sarcoma

Our experience with sarcoma has been limited. Comparatively few patients with sarcoma have been submitted to us for treatment.

Eight patients with lymphosarcoma have been treated. All have shown a remarkable immediate effect. Two have remained in a state of complete clinical retrogression up to the present time.

The clinical record of these patients is as follows:

Case R. M. Hosp. No. 23211. Female, 68 years old.

Condition on Admission, May 12, 1916.—The left tonsil is enlarged to a mass ¾ inch in diameter, and this swelling is continuous with a mass of neoplastic tissue in the nasopharynx. The lymphatic glands in the submaxillary region and upper cervical region are enlarged.

Mx: Round cell sarcoma.

History.—Three months ago the patient first noticed a swell-

ing of the left tonsil, and one week later a swelling in the neck. Since this time the tonsil and cervical lymphatics have increased in size. At Bellevue Hospital a bit of tissue was removed for examination, and reported to be round cell sarcoma.

Treatment.

May 17, 1916: 2 tubes; 200 m.c.; 1.5 mm. platinum covered with rubber; to tonsil and behind; 4 hrs.

May 17, 1916: 8 plaques; 800 m.c.; 3 mm. lead and rubber; to neck; 8 hrs.

May 31, 1916: A superficial burn has developed both in the throat and in the skin of the neck.

July 5, 1916: The masses in the nasopharynx and in the neck have entirely retrogressed, and the burns are healed.

Dec. 18, 1916: Readmitted because of the appearance of a slough upon the soft palate and upper surface of the tongue. It presents every appearance of being a late radium necrosis.

Jan. 12, 1917: The slough is separating and whole region appears free from disease.

Feb. 12, 1917: All ulceration on the tongue and in the pharynx has healed, and there is no evidence of disease present.

May 1, 1917: Free from any evidence of disease.

Case F. P. Hosp. No. 23100. Female, 52 years old.

Condition on Admission, March 27, 1916.—The right tonsil is enlarged, forming a mass which is about the size of a small egg. Its surface is ulcerated and covered with soft nodules. There is some enlargement of the left tonsil. Together they nearly fill the pharynx and cause marked nasal obstruction. Small enlarged glands can be felt in both axillæ and inguinal regions.

Mx: Malignant lymphocytoma.

History.—She dates her disease from Oct. 14, 1914, when she caught cold. Three weeks later she could not breathe through her nose and became deaf. Six months before this time a painful tooth was extracted, associated with a temporary swelling beneath the jaw.

Treatment.

Mar. 29, 1916: 2 tubes; 200 m.c.; 0.6 mm. silver and rubber; to tumor; 4 hrs.

Following this treatment a rapid and clinically complete

retrogression of the growth took place. Letter Mar. 21, 1917, stating that she is still perfectly well.

Three patients have been greatly improved, showing at one time a complete retrogression of their disease.

The following record is an illustration:

Case J. B. Hosp. No. 23673. Male, 62 years old.

Primary and fairly early lymphosarcoma of the tonsil, with, however, glandular metastases in the neck. Brought to a stage of temporarily complete clinical retrogression by three treatments. Within the month the retrogression was complete.

Condition on Admission, August 8, 1916.—Upon the left tonsil is a large indurated ulcer with an irregular base and everted margins slightly raised above the level of the normal mucosa surrounding the lesion. The growth has infiltrated the adjoining portion of the tongue for about 1½ inches of its length; the floor of the mouth and the soft palate. The lymphatic glands beneath the upper third of the sternomastoid are enlarged, forming a nodular prominence 3 inches in diameter at its base.

Mx: Lymphosarcoma.

History.—He first noticed the swelling in his neck 2 months ago, and 2 to 3 weeks later discovered the ulcer within the mouth. He gives no history of repeated attacks of tonsillitis, and is only a moderate smoker and drinker.

Treatment.

Aug. 30, 1916: 3 tubes; 126 m.c.; 1 mm. rubber-covered platinum; to ulcer on tongue and tonsil; 6 hrs.

12 plaques; 600 m.c.; 3 mm. lead, 2 cm. wood; to left side of neck; 12 hrs.

Sept. 18, 1916: The tumor on the neck has reduced to 50 per cent. of its original size and the ulcer on the tonsil is about healed.

Oct. 29, 1916: A glandular tumor has developed on the right side of the neck.

Oct. 29, 1916: 12 plaques; 720 m.c.; 3 mm. lead, 2 cm. wood; to right side of neck; 12 hrs.

Dec. 9, 1916: There has been a recurrence of the tumor on the left side of the neck.

Dec. 9, 1916: 12 plaques; 840 m.c.; 3 mm. lead, 3 cm. wood; to left side of neck; 10 hrs.

Jan. 10, 1917: No evidence of disease inside the mouth or in the neck.

Feb. 9, 1917: There is some increase in the size of the glands on the left side of the neck and some exophthalmos.

Feb. 9, 1917: 9 plaques; 1035 m.c.; 2½ mm. lead, 3 cm. distant; to neck; 5½ hrs.

3 plaques; 345 m.c.; 2½ mm. lead, 3 cm. distant; to external wall of orbit; 7½ hrs.

Subsequent to this treatment the patient developed thoracic metastases and died.

Another patient entered the hospital with the most distressing symptoms. Exophthalmos, due to intra-orbital tumors, and dysphagia, due to intra-oral tumors, and dyspnea, due to a large intralaryngeal tumor, were all marked. Comparatively short exposures to radium caused these masses to disappear and relieved these urgent symptoms. A continued generalization of the growth caused her death, however, in only a few months' time.

How much can be accomplished with these tumors depends largely upon the type of growth. As has been often demonstrated, there is every gradation in these tumors, between simple granulomata and the most malignant lymphosarcoma. In the case of the former it is possible to hope for a permanent cure.

Unquestionably some of the more malignant forms in their earlier stages are more closely allied to granulomata; and therefore, a larger proportion of the whole group may be cured by treatment in the earliest stages.

One fact of great importance is the circumstance that many tumors of this group begin in the tonsil. In such instances it is useless and harmful to remove the tonsil. A recurrence will surely follow in the lymph nodes. It is not impossible to recognize such tonsils. The sudden enlargement of a tonsil without acute symptoms in an adult should excite suspicion. A more favorable prognosis should be expected if the enlarged tonsil is treated with radium, instead of by excision.

The following case record is an illustration of this group:

Case S. R. Hosp. No. 23814. Male, 31 years old.

Lymphosarcoma of right tonsil and right cervical lymph nodes. A complete objective retrogression, but a failure to the present time to relieve the pain referred to the ear.

Condition on Admission, October 17, 1916.—Upon the right side of the neck there is a cicatrix 4 inches long. Beneath this there is a diffuse nodular swelling. In front of the ear just below the zygoma there is a small separate nodule about the size of a small marble. There are no supraclavicular nodes, but in each axilla there is a separate node. The one in the right axilla is soft and about the size of a walnut. The general condition of the patient is poor. He has some discharge from his nose, and feels prostrated. He also has a good deal of pain in the ear.

History.—One year ago he began having a pain in the right ear. The pain was intermittent, lasting 4 to 5 hours at a time each day, and severe enough to require aspirin for its relief. The right tonsil became somewhat enlarged. Four months ago a bloody discharge came from the nose. Eight or nine weeks ago the tonsil was removed. The antrum was irrigated and the enlarged glands in the neck were dissected out. Since then the glandular swelling has recurred and grown to the present size.

Treatment.

Oct. 17, 1916: 9 plaques; 540 m.c.; 2 mm. lead, 2 cm. wood, 1 cm. gauze; to right side of neck; 18 hrs.

Oct. 18, 1916: 3 plaques; 150 m.c.; 3 mm. lead, gauze cover; to front of ear to both axillæ; 4 hrs.

Oct. 28, 1916: The entire condition of the patient has changed. He is relatively free from discomfort and the glandular tumors have disappeared.

Nov. 13, 1916: 16 plaques; 960 m.c.; 1 mm. platinum, 2 cm. wood; to right side of neck and face; 15 hrs.

Subsequent to this treatment the patient developed recurrence in the sphenomaxillary fossa accompanied with a recurrence of great pain and a progressive deterioration of his general condition.

As might be expected the giant cell sarcomata of bone yield readily to radium. The only form of this tumor which we have had the opportunity to treat is the epulides of the jaws. These

melt away with single radium treatments of only moderate dosage. The records of six of these patients have already been given with the other malignant tumors of the lower jaw.

Certain spindle cell sarcomata have responded well to radium, and do so well that only the destruction already wrought by the tumor and the possibility of internal metastases (for the only tumors of this class which we have had an opportunity to treat were of very large size) have marred the success obtained by treatments.

The following case record is an illustration:

Case H. P. Hosp. No. 23721. Male, 20 years old.

Condition on Admission, September 18, 1916.—The lower third of the fibula and tibia is surrounded by a fusiform enlargement, measuring 14½ inches in circumference. The lower margin of the swelling is in the groove between the dorsum of the foot and the anterior surface of the leg, and on the external surface of the leg it extends to 1 inch above the plantar surface of the foot. The total length of the swelling is 5 inches. Upon the external aspect of the swelling is a large ulcer, 2½ inches in diameter, with a soft nodular base of evident neoplastic tissue.

History.—In August, 1915, he suddenly turned and twisted his ankle, after which it became swollen. After one week's disability he was able to use it with increasing liberty, until Feb., 1916, when the disability returned, and he became unable to bear his weight on the leg, and the leg became again swollen up to the knee. An incision was now made into the lower portion of the leg under the suspicion that pus was present, though he had no fever, but no pus was found. After this incision some of the diffuse swelling in the leg diminished, and he again became able to bear his weight upon it until July, 1916, when the swelling in the lower portion of the leg became larger. On July 11, 1916, it was evident that a tumor was growing in the lower end of the fibula, and an attempt was made to remove it. Since this operation the patient has been unable to use the leg and the tumor has rapidly recurred from the base of the cavity left by the operation and progressively grown to the present size when he entered the Memorial Hospital.

Treatment.

Sept. 19, 1916: 12 plaques; 444 m.c.; 3 mm. lead, 2 cm. wood; over ulcer on tumor; 24 hrs.

Sept. 29, 1916: 12 plaques; 900 m.c.; 3 mm. lead, 2 cm. wood; over three places on leg; 8 hrs. on each place.

Following this treatment there has been a progressive diminution in the size of the tumor.

Oct. 11 the circumference of the leg measured 13⅜ inches.

Oct. 18 it measured 12¾ inches.

Nov. 1 it measured 12¼ inches.

Nov. 15 it measured 12 inches.

Nov. 29 it measured 11½ inches.

Dec. 13 it measured 11¼ inches and the ulcer 3⅜ x 1⅝ inches.

Jan. 6, 1917: Referred to the *x*-ray department for treatment of a pulmonary metastasis revealed by a radiographic examination.

With other sarcomata strong treatment appeared to have only a limited success. These, however, were of large size, and the observation short.

The following case record is a fair representative of this group.

Case E. B. Hosp. No. 23329. Male, 11 years old.

Huge sarcoma of the upper end of the humerus. Unaffected by direct application to the surface of the skin in as strong a dosage as this method permits.

Condition on Admission. April 16, 1916.—The right shoulder is the seat of a fusiform swelling, due apparently to a tumor surrounding the upper extremity of the humerus. The tumor does not involve the clavicle or the scapula. The vertical circumference of the right shoulder joint is 18¼ inches,—of the left, 13½. The horizontal circumference of the arm measured just beneath the axillary folds of the right is 13¾,—of the left, 9¼. The whole arm below is edematous.

History.—In Jan., 1916, a small lump, ½ inch in diameter, appeared on the inner aspect of the upper extremity of the humerus. Some operation, leaving a long vertical scar on the anterior aspect of the swelling, was undertaken on Mar. 11,

1916, and since this operation the tumor has rapidly grown. He has no cough or loss of weight. Family history is negative. His previous health has been good. In Dec., 1915, he received a wound by a rusty nail to the middle finger of the right hand.

Treatment.

Apr. 15, 1916: 12 plaques; 900 m.c.; 3 mm. lead and rubber; to 3 areas surrounding tumor; 4 hrs. in each place.

June 17, 1915: Discharged from the hospital unimproved. No diminution in the size of the tumor.

In two patients with osteosarcoma an apparent cessation of growth took place. No essential diminution in the size of the tumor occurred in either patient, and this circumstance, as in the case of the cartilaginous tumors of the parotid, is but natural, as absorption of the new bone formed in the case of these tumors was not to be expected.

The clinical record of one of these patients is as follows:

Case S. H. Hosp. No. 23882. Male, 23 years old.

Large hard sarcoma of the lower extremity of the femur, containing much bone or cartilage. Checked in its previous continuous increase in size by two applications.

Condition on Admission, June 27, 1916.—The lower extremity of the right femur is enlarged in all directions, its circumference measuring 17½ inches. The surface of the enlarged portion is nodular, and its consistency is very hard. The patient feels considerable pain in the leg, especially at night. Walking increases the pain. He is unable to flex the limb through an arc of more than 25 degrees.

History.—Six months ago the patient felt pain in the right knee joint. Two months ago he noticed that the lower extremity of the right femur was enlarged. The enlargement first appeared on the inner side of the bone. It has steadily increased to its present size.

Treatment.

July 5, 1916: 14 plaques; 840 m.c.; 3 mm. lead, 2 cm. wood; to surface of mass; 8 hrs.

repeated in two other places.

Sept. 6, 1916: 12 plaques; 780 m.c.; 3 mm. lead, 2 cm. wood; to surface of mass; 12 hrs.

Following the treatment the tumor ceased increasing in size. The circumference on Sept. 12 was 17¾, and on Oct. 31, 17 inches. The pain diminished and the patient became able to flex the knee to an angle of 45 degrees.

Nov. 12, 1916: 12 plaques; 780 m.c.; 3 mm. lead, 2 cm. wood; to leg; 12 hrs.

12 plaques; 720 m.c.; 3 mm. lead, 2 cm. wood; to leg; 12 hrs.

A radiograph now shows thoracic metastases, but the process in the femur is stationary.

We have produced a remarkable retrogression in a metastatic round cell sarcoma of the orbit and nasal cavities, following an operation for a primary sarcoma of the breast. The relief to this patient was so great that a summary of her clinical record is desirable.

Case L. L. Hosp. No. 24031. Female, 61 years old.

Metastatic sarcoma of the orbit and nose, from a primary growth of the breast. One treatment, with a complete disappearance of the tumor.

Condition on Admission, December 27, 1916.—The left eye protrudes forward and to the left, and surrounding it above and to the inner side is a large, rather firm, mass extending over the bridge of the nose and upward upon the forehead. The skin over the mass is red and somewhat adherent. Near the eye this is ulcerated, and from the conjunctiva there is a mucopurulent discharge. The vision in the left eye is much reduced. The left nostril is occluded with a mass of neoplastic tissue which is covered with a mucopurulent discharge.

Mx: Round cell sarcoma.

History.—In Aug., 1916, the patient noticed a small nodule at the inner canthus of the left eye, about the size of a bean. This rapidly increased in size. At the same time a lump appeared in the neck below the angle of the jaw. This enlarged to the size of a hen's egg and was excised Nov. 22, 1916.

Treatment.

Dec. 27, 1916: 9 plaques; 587 m.c.; 2 mm. lead, 3 cm. wood; to lesion; 12 hrs.

Jan. 2, 1917: The mass around the eye has disappeared and

the left nasal passage is free; and the vision of the left eye has greatly improved.

Our conclusions regarding the treatment of sarcoma by radium are:

1. It is the most efficient method of dealing with lymphosarcomata, affording relief from urgent symptoms in advanced cases, and possibly a permanent retrogression in certain varieties of the early cases.

2. It is the method of choice in the treatment of giant cell sarcoma of the bones. Bloodgood (*Annals of Surgery,* 1912, LVI, 210) has shown that these tumors are not to be regarded as malignant tumors. They probably never metastasize, so that local treatment is always indicated.

3. In other forms of sarcoma it is the method of choice if pulmonary metastases can be demonstrated.

The rarity with which the more malignant forms of periosteal sarcoma are cured by amputation raises the question of how serious in any case of sarcoma is the injustice which would be done to a patient if these are treated primarily by radium instead of by amputation. Until, however, more exact information is available regarding the completeness of the influence of radium on periosteal sarcoma, it will be wiser to reserve periosteal sarcoma for amputation, unless pulmonary metastases can be demonstrated or the patient refuses operation.

The Treatment of Gliomata

One patient with advanced recurrent glioma of the brain has been treated. The cranial cavity was reopened and two radium tubes were imbedded within the tumor substance. The patient left the hospital before the effect of the treatment could really be ascertained. The immediate result was good. His clinical history is as follows:

Case D. F. Hosp. No. 23572. Male, 23 years old.

Glioma of the brain. Craniotomy and insertion of tubes of radium within the substance of the tumor.

Condition on Admission, August 5, 1916.—Protruding from a large defect in the cranium in the anterior parietal region are

two soft, elastic, rounded tumors, elevating the skin of the scalp about 1 inch. These tumors cover an area 3 inches in diameter. The patient's mental condition appears to be good, and he has no disturbance of speech or motion or sensation.

Mx: Glioma.

History.—Four months ago he developed symptoms for which a cerebral decompression was performed. The present tumor has gradually increased in size to the present time.

Treatment.

Aug. 5, 1916: 2 tubes; 56 m.c.; platinum and rubber; within the tumor; 6 hrs.

Following this treatment there was no change in the size of the tumor and he left the hospital unimproved.

We have treated also one large chondroma of the ileum, but with little success, although a cessation of the further increase in size of the growth may have been attained, yet the failure to cause chondromata to disappear will always make operation combined with the application of radium to the pedicle, the method of choice in the treatment of chondrosarcoma.

Nevi

A number of cases of nevi have been treated. Nevi yield with especial susceptibility to radium. No form of application of radium serves so well in the treatment of superficial nevi as active deposit, collected on lead and laid upon the surface.

GENERAL CONCLUSIONS

In classifying the patients presented in this report the most favorable results have been grouped in a class including all patients who at one time showed a complete disappearance of the objective signs of their disease. A subdivision of this class includes those patients who have remained well one year from the time the treatment was begun.

This method of classification has been adopted because our active work with radium is now not over two years old, and it is consequently impossible for us to speak of cures.

The remaining patients are classed as improved and unimproved. A subdivision of the improved class shows those who are still under treatment. A few patients have been treated prophylactically.

Grouped according to this manner the following table has been prepared:

Location of Lesion	Patients Who at One Time Reached a Clinically Complete Retrogression	Patients Who are Free from Recurrence for 1 Year or Longer Exclusive of Skin Cancer and Giant Cell Sarcoma	Improved	Under Treatment	Prophylactic	Unimproved	Benign	Total
Lip	6	4	6	1	...	12	...	24
Nose	..	..	...	...	...	2	1	3
Superior maxilla	4	2	11	2	1	9	..	25
Cheek	4	2	3	3	1	3	...	11
Lower jaw	1	..	5	3	...	6	..	12
Epulides	5	..	..	..	...	..	..	5
Floor of mouth	1	..	4	3	...	1	..	6
Cancer of tonsil	6	2	14	7	...	6	...	26
Cancer of tongue	4	2	22	2	...	24	...	50
Cancer of larynx	4	..	7	...	...	16	...	27
Esophagus	1	1	6	1	...	15	...	22
Stomach	..	..	4	4	...	3	...	7
Rectum	3	1	13	7	...	18	...	34
Penis	1	..	4	3	1	2	...	8
Vulva	..	..	...	...	...	1	...	1
Uterus	4	1	2	2	...	2	1	9
Breast	1	1	8	2	3	9	...	21
Parotid	2	1	2	2	...	1	...	5
Neck	1	1	4	1	...	6	...	11
Teratoma	4	1	1	1	...	...	...	5
Skin	66	..	7	7	...	20	...	93
Lymphosarcoma	2	2	5	5	...	...	...	7
Sarcoma	..	..	6	3	...	6	...	12
Totals	120	21	134	59	6	162	2	424

When the details summed up in this table are studied it becomes apparent that radium, as a palliative agent in advanced cancer, has had in our hands a limited field of usefulness. Applied over the surface of the body at a distance it will cause retrogression of many tumors and relieve pain. Only too often both the direct and distant treatments, of sufficient intensity to cause marked retrogression, at least in advanced epidermoid carcinoma of the mucous membranes, are followed by an increase of pain for long periods.

In smaller doses radium performs much the same service as the *x*-ray. It is useful as a preliminary measure before operation, to control the activity of growth, in epidermoid cancer of the lymph nodes. In the more susceptible tumors, as lymphosarcoma, the malignant cellular teratomata, and even the adenocarcinomata, as for instance those of the stomach, radium gives much palliative relief. Its almost specific effect in the lymphosarcomata and teratomata clearly calls for its use in these diseases.

In other forms of advanced cancer any temporary benefit from its proper use is frequently overshadowed by the later progressive extension of the disease, an extension which, though more indolent, is quite as progressive and painful. We have been led to treat more of these patients than we otherwise would have treated because of the moral effect produced by doing something, even though accompanied by little benefit, for an individual for whom there was nothing else to do. This, however, is a poor basis for the study of any therapeutic measure.

It is important to recognize in undertaking the treatment of such patients, the character of the end result to be expected and to plan the treatment accordingly. No patient of this class should be given a treatment which will be followed by more than a transitory discomfort. Administration of several treatments will result in immediately making the patient very uncomfortable before his disease itself starts to do so in a still more aggravated way than before treatment. It is true that since we have approached a much more complete distribution of the radium over the surface of the growth we have been able to administer really strong and very much more effective treatments than formerly.

When, however, we come to consider another class of cases, the more circumscribed growths of the mucous membranes, with which, perhaps, radium performs its best service, an entirely different problem presents itself. Here a different end result may be expected, and it is good enough to warrant pushing the initial treatment further, when this is necessary, than in the case of patients treated palliatively, and especially so as smaller areas of tissue are concerned.

Few more malignant tumors, as estimated by its unchangeable progress to death, are known than epidermoid cancer of

mucous membranes. In its earliest stages and in locations where it can be liberally excised, it is sometimes cured by surgical removal; but what significance has this fact to an individual with such a growth of the anus, the esophagus, the larynx, the tonsil, the antrum, or even the tongue? In all these locations the case records grouped in this report prove that in early cases a complete clinical retrogression can be obtained by the proper application of radium, that such retrogressions can be obtained without the loss of even a portion of the organ in which the cancer is growing, and practically without interference in the patient's routine duties.

A complete clinical retrogression is not, however, a cure; and until sufficient time has elapsed to demonstrate the degree of permanency of the retrogressions accomplished in our patients, the value of the present report will be small from the viewpoint of many surgeons who are accustomed to give serious consideration only to those patients remaining well after a three- to five-year period.

Unquestionably in the minds of many the right to treat with radium an operable growth of the mucous membranes mentioned will be denied. Those responsible for the work undertaken at the Memorial Hospital, who have watched the character of the retrogressions accomplished by the use of radium in cancer of the mucous membranes, at first in cancer of doubtful operability of the tongue, lip and rectum, and then in inoperable cancer of small size, but rendered inoperable chiefly because of its location, as, for instance, cancer of the tonsil, and finally of clearly operable growths of these organs, in patients who refused operation, are convinced that the character of these retrogressions is so good that it is wrong not to use every opportunity at the present time to discover how far radium can be relied upon to cure primary early cancer.

As long as radium is tested out only upon the surgical derelicts and discards, its most useful possibilities will never be known. Its action on these is to-day sufficiently well known, and they fully justify its trial on the earliest lesions. In patient after patient it has caused a disappearance of all local evidence of disease at its primary site, even in some cases where the tumor was of large size. See cases No. 22980, page 86 (lip); 22731, page 92 (sup. maxilla); 23751, page 102 (cheek); 22-

245, page 123 (hard palate); 23061, page 124 (tonsil); 22687, page 144, or 23364, page 138 (tongue); 23715, page 172, and 23724, page 171 (rectum); 23027, page 180 (uterus); 23398, page 187 (breast); 23840, page 199 (teratoma testis); 22942, page 206 (skin); 23100, page 213 (lymphosarcoma); 23721, page 217 (small cell periosteal sarcoma).

It has caused important retrogressions of enlarged, secondarily involved lymph nodes in the neck in repeated instances: Hospital Case No. C. N. 23153, page 141; L. D. 22703, page 94; J. S. 23725, page 131; A. DeC. 24061, page 128; E. W. 23531, page 129.

Its controlling influence upon the growth of early metastases in the lymph nodes is of the greatest importance in connection with their subsequent removal. DeC. 24061, page 128; D. W. 23517, page 125.

If radium can do so much in advanced cancer, it is reasonable to believe that it will have the same complete action on early cancer without some of the disadvantages, the effect on the nerves, the fibrosis, and dermatitis of the skin, which have not always been avoided with the use of large amounts of radium. This expectation has been fulfilled in the early growths which we have treated, and the end result to date has been all that could be desired.

The only question remaining unanswered is, Are these patients free from the dangers of a recurrence? Cases 21666, page 90 (sup. maxilla); 22731, page 92 (sup. maxilla); 22251, page 84 (lip); 21999, page 179 (uterus), and 21371, page 175 (rectum), have gone two years and over. Familiarity with the character of the majority of the retrogressions cannot fail to leave the impression that many of them will prove permanent. The rather small percentage of apparent cures in the table above is of small significance when it is remembered that growths in all stages have been included in the data of which this table is composed, comparatively few patients who presented themselves for treatment during the past few years having been refused. This percentage of apparent cures is a very high percentage of favorable cases.

III

RADIUM TREATMENT OF BLADDER AND PROSTATIC CARCINOMA

B. S. Barringer, M.D.

This report is based upon twenty-five cases of carcinoma of the bladder, and thirty cases of carcinoma of the prostate treated by radium since Oct., 1915.

BLADDER CARCINOMA

In making a diagnosis of carcinoma of the bladder in these cases more stress has been placed upon the clinical findings than upon the microscopical examination. Such clinical findings making for malignancy are in order of their importance:

1. *Induration Revealed by Touch (Rectal or Vaginal) or by Cystoscopy.*—When a tumor feels hard one is much more certain of one's findings than when one sees (or thinks one sees), by means of the cystoscope, an induration of the base of the tumor. In the latter case the personal equation enters much more than in the former.

2. *Slough.*—Only malignant tumors slough. Such slough appears as grayish or whitish areas in the tumor mass. Here again one may err, and I have often been surprised how one's idea of a bladder tumor changes with subsequent cystoscopies. In difficult cases a number of cystoscopies may be necessary to accurately determine both the extent and the appearance of the tumor.

3. *Reaction to Fulguration.*—Keyes and Geraghty have called attention to this feature. Benign tumors are quickly burned off by fulguration. Malignant tumors react stubbornly or not at all.

4. *Age.*—The older the patient the more likelihood of carcinoma.

5. *Multiplicity and Size of Tumor.*—So-called benign papillomata are more apt to be multiple than carcinomata. The size of tumor rather speaks for difficulties in its removal than for malignancy.

The microscopical examination in twelve of the twenty-five cases has shown carcinoma. According to the microscopical examination these twelve are classified either as papillary or as diffuse carcinoma.

Application of Radium in Bladder Carcinoma

The technic of the application of the radium is: two capsules of screened radium (0.6 mm. of silver and 1.5 mm. of rubber) from 50 to 100 m.c. are placed in the bladder through the sheath of the cystoscope and allowed to remain there 6 to 8 hours. As 90 per cent. of bladder tumors are on the bladder base the radium so inserted is in close contact with the tumor. If the carcinoma is on the vault or lateral walls the patient lies on his abdomen or on one or the other side. After the treatment the radium is removed *per urethram* by a linen thread attached to the capsules.

The initial pain experienced is only that of the cystoscopy. The after-burn varies from none at all to more or less severe pain beginning a few days after treatment and lasting from one day to several weeks.

In extensive carcinoma involving the bladder sphincter irradiation may very much increase both the pain and the urinary frequency. It is to be used in these cases with caution.

Effect of Radium on Bladder Tumors

In a large majority of the cases in which I have applied radium to bladder tumors, the hematuria has stopped two or three days after the irradiation. There is a suggestion in this that the primary effect of the radium is upon the blood vessels. If this is so it would in a measure explain why papillomata of the bladder, rich in blood vessels, react somewhat more slowly to radium than true carcinomata which have poor and imperfectly developed blood vessels.

In some cases the rapidity of the action of radium is aston-

ishing. Case I, was irradiated Jan. 19, and on Feb. 4 (sixteen days later) cystoscopy showed that an extensive carcinoma had entirely disappeared.

Radium burns of normal portions of the bladder have occurred only in those cases in which the carcinoma was around the bladder neck, and in which the radium was pulled into the urethra and kept there for a long time. I have had two such cases; the burns last a long time, and cause considerable irritation. Division of the radium dose into two or more tubes; using somewhat smaller quantities; change in the position of the patient during application; and a fairly long interval between irradiations—six weeks or more—ought to prevent such burns.

Summary of Cases

Two of the twenty-five cases of carcinoma of the bladder treated would have been considered good operative risks, the other twenty-three cases because of the extent of the tumors were all impossible operative risks. In four of the twenty-five cases (three confirmed microscopically as carcinoma) radium has locally removed the growth. One of these has been cystoscopically cured for 10½ months, one for 5 months and one recently. One has what is probably a slight local recurrence although microscopical examination of a piece removed does not confirm this view. These four cases are of sufficient interest to report in some detail:

Case I: *Signs of Malignancy.*—Large tumor, vaginal induration not determined; sloughy in part; microscopical diagnosis of carcinoma; fulgurated twice, and no headway; age 69.

C. A. G. *History.*—Chief complaint urinary frequency for the past year, night 3 to 4 times, day every 3 to 4 hours; pain following urination. She had been passing bloody urine for the past four months. A number of months before I saw her she was cystoscoped, and a diagnosis made of inoperable carcinoma. Cystoscopy showed large red carcinoma with necrotic patches on left side of bladder obscuring left ureteral orifice. Tumor was probably as large as a fifty-cent piece. Specimen removed showed (Dr. Ewing) "The section is of a small mass of tumor

tissue 2 mm. in diameter. It shows the structure of a small alveolar carcinoma, much inflamed, with dilated blood vessels. The cells are clear, irregular in size, with large hyperchromatic nuclei, and arranged in small groups. The stroma is scanty."

Jan. 19, 1916, 100 m.c. of screened radium in bladder for eight hours.

Feb. 4, she reported that she had some frequency and severe bladder pain for two days; then everything normal. Cystoscopy (with Drs. Keyes and Jeck) showed that the tumor had gone, the area was covered with normal mucous membrane, and the ureter visible.

Dec. 19, she had a stellate, white scar over place occupied by tumor. No tumor visible. Reduplication of ureter.

Case II: *Signs of Malignancy.*—Tumor as large as a ten-cent piece; no induration; ulcerated tumor; microscopical diagnosis of carcinoma; fulgurated four times in six months and recurred. Age 59.

C. T. *History.*—Eight months before had occasional attacks of painless hematuria. He was cystoscoped and a papilloma near the left ureter was seen. This was burned with high frequency four times in about six months, but had always recurred. Dr. Keyes saw it in Jan., 1916, when it was an ulcerated area with carcinomatous looking lumps. A piece removed showed diffuse carcinoma (Dr. Ewing).

"The section is from a mass of tumor tissue 5 mm. in diameter. It presents a small alveolar and diffuse carcinomatous structure. The cells are extremely atypical, and some are of very large size, with very hyperchromatic nuclei. The outer portions are hydropic, the central areas show fibrosis, and here the tumor cells run in narrow rows or small groups."

Feb. 11, 1916, 214 m.c. of screened radium for seven hours.

May 2, cystoscopy showed normal mucous membrane over the space occupied by the carcinoma. He had had 7 or 8 erections since treatment, while he had been practically impotent for 10 years before.

July, he had gained 10 pounds. Cystoscopy (Dr. Ballinger) negative.

On Nov. 8, Dr. Ballinger reports "has passed no more blood. Cystoscopy about a month ago showed only a reddened place

where the growth was. There has been a rather persistent cystitis."

Case III: *Signs of Malignancy.*—Extensive tumor; vaginal induration as large as a silver dollar; sloughy in part; microscopical diagnosis of papillomata; no fulguration; age 54.

Mrs. E. H. S. *History.*—Chief complaint hematuria for the past year, and urinary frequency at night 5 to 20 times. Cystoscopy showed grape-like, red, partly sloughy tumor around the bladder neck. Vaginally there was an indurated area of the base of the bladder, nearly as large as a silver dollar. Specimen removed was reported as being papilloma (Dr. Ewing). Because of the induration, and because of the slough, I considered this carcinoma.

July 6, 116 m.c. of radium in bladder neck for 6 hours. Reported one month later that she had a little discomfort in passing urine for a few days. She had gained 15 pounds in weight; got up but twice at night to urinate.

Aug. 29, she still had tumor around bladder neck. 100 m.c. of radium in bladder neck for 8 hours. She had no hematuria since the first radium.

Oct. 30, 1916, reports she had no pain after the radium. Cystoscopy showed the tumor to be gone. She had gained 18 pounds in all. No induration of bladder base. Had no night urinary frequency.

Case IV: *Signs of Malignancy.*—Tumor as large as a quarter; induration shown by cystoscopy; sloughy; microscopical diagnosis of carcinoma; fulgurated twice, and tumor grown 2 or 3 times its original size; age 62.

J. A. H. *History.*—Had two attacks of total hematuria, one month and eight days before seen. No night frequency; no loss of weight. Dr. Keyes saw by cystoscopy a red, lobulated, rather flat, carcinoma above right ureter; burned it with high frequency and advised radium. The patient went to another physician who fulgurated the tumor and decided against both operation and radium. About three months later he returned when (with Dr. Keyes) a flat, sloughy in part, carcinoma was shown, two or three times the original size, extending from

bladder neck to a point 2 cm. above right ureter. It had raised, thick, indurated edges. A specimen removed showed (Dr. Ewing) carcinoma. Two tubes of screened radium (one 90 and one 89 m.c.) were left in his bladder 6 hours.

Two months later he returned when there was seen redness of right side of his bladder, a small ulcer back of ureter (well away from where the tumor was) probably due to radium burn. *No other lesion was seen.*

Two months later there was a linear ulcer 1 cm. long, surrounded by puckered red mucosa on the anterior end of his original tumor. It looked like a recurrence although a piece removed shows no carcinoma. Treated again by radium.

From results in these four cases it appears that radium can do as much as surgery for cases of bladder carcinoma without subjecting the patient to the danger and discomfort of a major operation. While these cases are entirely too few upon which to base any permanent deductions, I believe at the present time that the local removal of bladder carcinomata by radium depends upon two factors:

First, to get cases early enough, and second, to actually apply the radium to the carcinoma.

Of the *twenty-one remaining cases,* eight have died, two as the result of transplantation of the ureters. Two are improving; one of these is a hopeless case, and one I have hopes of curing. Four I have not heard from since the irradiation, and the rest are too recently treated to report on.

These statistics are not brilliant, but one must remember that these twenty-one cases were all advanced carcinomata and that all but one or two in which a thought of cystectomy might have been entertained were totally inoperable. A certain number of these hopeless cases were benefited by the irradiation. Some have gained weight and in nearly all the hematuria has stopped. One patient, known to have lymphatic involvement beyond the bladder, came to me with a suprapubic opening (the result of an operation) as large as my index finger. Two months after one radium treatment he had gained ten pounds in weight, his bleeding had entirely stopped, and his suprapubic wound closed; this notwithstanding the fact that his entire bladder was a mass of carcinoma.

Indications for the Use of Radium

The question remains, In what cases are we to use radium? I believe, first, that radium should be tried in all those cases in which we have reason to think the carcinoma is confined to the bladder, to see what the radium will do, much as fulguration has been used as a diagnostic test of carcinoma. The second indication is hemorrhage from a bladder carcinoma. One dose of radium seems to pretty consistently check this symptom.

CARCINOMA OF THE PROSTATE

From thirty cases of carcinoma of the prostate treated by radium since Oct., 1915, the following conclusions have been derived:

1. Radium treatment has caused with surprising regularity the reduction or disappearance of carcinomatous nodules of the prostate. Striking results have been obtained both in early and advanced cases. The early cases, those in which the carcinoma is fairly well confined to the prostate and in which there is little or no perivesicular infiltration, show shrinkage of the carcinoma. Very few of the advanced cases, those in which there is an enormous prostate and in which the vesicles are hard and indurated, show any improvement.

2. The reduction which occurs in carcinomatous lobes is, as far as has been observed, permanent. One case has been followed for fifteen months, two for eight months, and more recent cases about a month or two after the reduction.

3. The symptoms in those cases in which the carcinoma has been reduced show striking improvement. This symptomatic improvement is shown in increased weight and strength, decrease in frequency of urination and return of or improvement in erections. One patient of 74 years, on whom a suprapubic exploration showed carcinoma of the prostate and who was treated but once with radium, gained eight pounds and reported five months later that he was then "Doing a full day's work on steam boilers." He narrated on questioning that a full day's work was from 5 a. m. to 11 p. m.

Another who had no erections for 1½ years had a permanent

return of this function. This patient who had been invalided gained 18 pounds, started in the mild work of shoveling snow and lifting ash cans and now is doing a full day's work in a machine shop 16 months after his first treatment.

4. The technic of the radium application is as follows:

The emanations are placed in the end of a needle (gold or steel) extending from the tip 1½ inches along the sheath. These needles are 4 to 6 inches long, and are inserted through the perineum into the prostate or further into the vesicles. The perineum is anesthetized with 0.5 per cent. novocain and epinephrin which makes the insertion practically painless. The needle is left in one lobe for six hours and then transferred to the other lobe. A finger in the rectum is used to guide the needle. Little or no pain is felt during the sojourn of the needle (12 hours) and the patient can either urinate or be catheterized. This means at most but twenty-four hours in the hospital. Fifty m.c. of radium are used in the end of the needle. Radium used in this way is practically unscreened and the maximum effect of the radium takes place directly in the center of the carcinomatous nodule. The patient usually has pain in the prostate and urinary frequency beginning about 3 days after irradiation, and lasting a number of days to some weeks. In some cases in which I have used large doses the reaction has been severe. One has to be extremely careful about second or subsequent irradiations; the tissue seems to be much more sensitive to radium after the initial dose. Nearly all of my patients have been irradiated but once in two or three months, and no second treatment is given until the effect of the radium has entirely passed over.

5. The primary effect of the radium may be to increase the amount of residual urine (if there be any). The ultimate effect of the radium application on residual urine is probably nil, the amount neither increasing nor decreasing. Hence those patients who have chronic retention of urine require either the catheter or operation in addition to irradiation. It would seem wiser not to operate until the carcinomatous prostate had been thoroughly irradiated, and it would seem better not to operate at all if the patient can be trained to the use of the catheter.

6. No sloughs have resulted from the radium needles.

7. Radium apparently has a selective action on carcinoma.

I conclude this from descriptions by Dr. James Ewing of carcinomata examined after radium treatment and from my own experience. I have used radium on an hypertrophied prostate with absolutely no effect, neither burning nor shrinkage occurring, yet the same amount of radium will markedly reduce a carcinomatous lobe. I have had a similar experience in a case of chronic contractive fibrosis of the corpora cavernosa.

8. The pathological examination of prostates removed after irradiation is of interest. In one case in which the prostate was removed because of urinary retention a moderate dose of radium was given five months before the prostatectomy. The prostate had been considerably reduced in size following the radium treatment. Dr. Ewing reported as follows:

"Material consists of several lobulated opaque portions of prostate making a mass as large as a hen's egg. Much of this has the honey-comb appearance of chronic prostatitis. But some areas are very firm and solid. Two such areas, size of a bean, were sectioned. The main tissue of the gland shows lesions of chronic prostatitis with dilated glands and feeble epithelial proliferation. The solid areas show fibers of muscle tissue separated by rows of small epithelial cells with hyperchromatic nuclei. The appearance is that of diffuse carcinoma in a state of fibrosis. One area of adenocarcinoma is found in the center of a fibrosed area. There is no necrosis.

"In view of the history the diagnosis may be made of carcinoma, diffuse and adeno, arising on prostatitis, and undergoing atrophy and fibrosis from radium."

In another patient I gave one large dose of radium in Aug., 1916; the patient had a severe reaction. Five months later because of retention I took out as much of the prostate as I could. The pathological examination is as follows (Dr. Ewing):

"Portions of material including a segment of urethra received. They show subacute inflammation, hemorrhage and regressing changes in an alveolar carcinoma. The tumor alveoli are represented by groups of 5 to 10 epithelial cells with homogeneous nuclei, clear cytoplasm, lying in dense fibromuscular tissue. Traces of these alveoli disappear in the exudate of round cells in many places."

It will be necessary to examine many more prostates which

have been treated by radium before one can be sure that the above changes are due to the radium. The fact that carcinomatous lumps retrogress after radium treatment is "corroborative evidence" that radium causes a fibrosis in the carcinoma.

9. As far as I have observed clinically all the cases treated are of about the same degree of malignancy. There is a class of cases of prostatic carcinoma, however, of much more marked

FIG. 17.—PROSTATIC CARCINOMA UNDERGOING FIBROSIS AND ATROPHY FROM RADIUM TREATMENT

malignancy. In these the primary focus in the prostate is often overlooked, and the patient comes to be treated for a secondary focus. There have been two such cases at the Memorial Hospital in both of which there was a large carcinoma of the neck and it was only by examination in one case and necropsy in the other that the primary focus in the prostate was found. Such cases are apparently very malignant and it is a question if we ever get them early enough for any treatment to count.

10. Very large carcinomata with cachexia and loss of weight are beyond radium or any other treatment.

11. Only time will tell us whether any of our patients have been cured. At the present time we can state that in fairly early cases a marked regression of the prostatic lumps, and in

FIG. 18.—PROSTATIC CARCINOMA UNDERGOING FIBROSIS AND ATROPHY FROM RADIUM TREATMENT

some cases a complete disappearance of these, has taken place. Accompanying this retrogression the patients have improved in weight and bodily strength. Radium has done more for these cases than operation or any other known therapy.

Summary of Prostatic Cases

Thirty cases of prostatic carcinoma have been treated.

ADVANCED CASES.—Nineteen of these thirty cases were advanced, having either very large prostates or marked perivesicular involvement or both. In four cases the carcinoma had

directly invaded the bladder. In eleven of these nineteen a microscopical diagnosis of carcinoma has been made. Four of these nineteen have died. One is going rapidly downhill, one has been lost track of, but six months after a single treatment was reported as up and working. In three cases I have done a partial prostatectomy for retention after treating the carcinoma with radium. Two cases are distinctly improved. The remaining cases have been too recently treated to report, as it takes from four to six months to get any results from irradiation. The two improved cases are worth reporting:

Case IX: M. H. *History.*—Age 65. Had a sloughy pedunculated carcinoma removed from neck of the bladder by Dr. Keyes. This grew from the prostate, no removal of which was attempted. The pathological examination (by Dr. Ewing) was as follows:

"The section is from a piece of tumor tissue 0.5 cm. in diameter. It shows a solid carcinoma composed of small and large groups of compact tumor cells with a very little stroma. The cells are of moderate size, polyhedral, with hyperchromatic nuclei. The vessels are scanty. There is no necrosis. It is impossible to state from the section whether there is any infiltration of the bladder wall. In structure the tumor is that of a fully developed carcinoma."

June 6, the right lobe of the prostate which had a hard ridge was treated with 93 m.c. of radium for six hours.

Sept. 12, patient did not have to rise at night, he went from 4 to 6 hours without urinating, he had gained 15 pounds, and the lump in the right lobe was about gone. There was infiltration running up into the right vesicle. (Examination with Drs. Keyes and Jeck.)

Mar. 1, he still showed some induration of the right vesicle. He was doing a full day's work and has lost no weight.

Case X: J. B. B. *History.*—Age 75. History of night frequency of urination, 2 to 6 times, for some months. Residual urine 2 to 3 ounces. No loss of weight. Prostatic examination (with Dr. Keyes) showed an extensive lumpy carcinoma running into both vesicles, a little higher on the right side.

June 6, 99 m.c. of radium in his right lobe for 6½ hours and left lobe for 5 hours.

Oct. 9, patient had a very severe reaction with much pain lasting from 4 to 6 weeks. During this time he lost 12 pounds. Examination of the prostate (with Dr. Keyes) shows that much of the prostatic carcinoma is gone, periprostatic region was still carcinomatous as is also the region of the vesicles. He looked in excellent shape and had regained his weight. I treated the remaining carcinoma with radium, not with any hope of curing him, but with the hope of stopping the growth for a time. In February he was reported as vacating in Florida.

Early Cases.—Eleven of the thirty cases were, roughly speaking, early carcinoma. This does not mean that they were suitable for operation. As a matter of fact because of the initial success of radium treatment I believe that no patient with prostatic carcinoma should be operated upon. With one of the eleven cases there was a question of the diagnosis. One of the eleven died four months after prostatectomy from the effects of the operation and old age (82 years). Six of the eleven cases are distinctly better, and the remaining four cases have been too recently treated to report upon. The histories of these six are, briefly:

Case I: J. C. D. *History.*—Age 59. Chief complaint loss of flesh and strength, night urinary frequency 3 to 4 times for 4 months. Pain in right thigh for 5 years. Prostatic examination (with Dr. Keyes) showed a large, hard, fixed, irregular prostate, each lobe about as large as half an English walnut, left lobe more prominent than right, little extension toward seminal vesicles. Radium treatment Oct. 20, 1915. Fifty m.c. in left lobe 6 hours, and in right lobe a similar time.

Nov. 17, 1915, reported that he had considerable burning after the treatment, and that he had a number of erections since (erections had been lost for 1½ years). Prostate felt the same.

Jan. 14, 1916, he had gained about 10 pounds; felt fine (examination of prostate with Dr. Keyes). There was a marked shrinkage of the carcinoma. Dr. Keyes said "it is more the slight irregularity of the prostate that suggests carcinoma than

anything else." I gave him 60 m.c. of radium for 4 hours in both lobes.

Jan. 31, 1916, he had gained 6 pounds more, making 16 in all, and had no pain from the radium; arose once at night to urinate.

Feb. 18, 1916, not up at all at night to urinate, gained 2 more pounds in weight. Slight induration at base of the prostate, 38 m.c. of radium in right lobe for 8½ hrs.

Apr. 4, 1916, 75 m.c. in right lobe for 4 hours, then in left lobe 4 hours.

June 30, he had been working in the machine shop for 6 weeks, and had lost a couple of pounds. Had some burn after the radium which has caused increase in night urination (3 to 4 times). In the center of the left lobe there was a small, fairly hard lump, and a slight hard ridge in the right lobe.

Nov. 17, weight the same. Working (sometimes 15 hours a day). A ridge in either lobe. I could not say whether or not it was carcinomatous.

Feb. 12, examination of the prostate the same. Fine condition. Doing a full day's work. Again treated with radium.

Case III.—J. J. C. Age 71. Chief complaint is urinary frequency, chiefly at night (3 to 4 times) for the past 6 months, then acute retention. He had lost about 8 pounds in weight. Prostatic examination showed a flat, hard, irregular prostate with prominent nodules at prostatovesicular junction extending into the vesicles. (Examination with Dr. Keyes.) Several other physicians examined the case and thought the diagnosis was not positive, but that it was very suspicious of carcinoma. Forty-five m.c. of radium in right lobe for 7 hours, and in left lobe for 5½ hours (Feb. 8, 1916).

Mar. 17, 1916, reported not up at all at night to urinate, doing a full day's work and no pain at all after the radium.

May 23, the radium was repeated after which he had pain and frequency of urination for a few days.

Oct. 16 (examination with Dr. Keyes). Lost 2 or 3 pounds, is the picture of health. He had never been catheterized since beginning the radium treatment. A nodule the size of a pea at the right prostatovesicular junction, nothing in vesicle or along upper border of prostate. There was a ridge along lateral

edge of right lobe not extending beyond the prostate, nothing in vesicles.

Jan. 15, he had lumps at either upper margin of his prostate. If anything they had increased in size. He was doing a full day's work, and was in excellent condition. Again treated with radium, 62 m.c. in right lobe 6 hours, and 6 hours in left lobe.

Case VI.—W. C. Age 58. Chief complaint slight increase in frequency of urination (once at night). (Examination of prostate with Drs. Keyes, MacKenzie and Jeck.) Left lobe of prostate soft; right lobe hard, nodular, not large. Nothing in vesicles.

May 23, 50 m.c. of radium in right lobe 11½ hours.

Aug. 29, had pain after the radium, his symptoms were the same, and the prostatic carcinoma feels the same. 100 m.c. of radium 4 hours in right lobe.

Nov. 8, carcinomatous lump feels the same. He had some hematuria for 2 days. There was a slight irregularity of the lateral lobes of his prostate as seen by cystoscope. 102 m.c. of radium in his urethra for 6 hours.

Jan. 26, not up at all at night. Still working a full day. Prostate felt the same as when first examined. 64 m.c. in right lobe 6 hours, and left lobe 6 hours.

Feb. 13, the lump in his right lobe was apparently about gone. He had considerable burning after his radium, and he was now getting over the effect of this.

Case XV.—A. S. Age 68. This patient was operated upon by Dr. Keyes in the spring of 1916 for hypertrophied prostate. Pathological examination of the removed prostate showed no malignancy. He came back to Bellevue in September with a hernia upon which I operated at the same time taking out a small prostatic lobe in the floor of his urethra. This proved to be carcinoma on pathological examination. He weighed 168 pounds before the operation. Rectal examination revealed a diffuse infiltration over the bladder base with some slight lumps. (Examination with Dr. Keyes.)

Oct. 17, 57 m.c. of radium was inserted for 6 hours in the middle of his prostate.

Dec. 4, had gained 20 pounds, erections had improved, he

had a solid, hard lump at the apex (left) of his prostate; all the rest felt pretty soft.

Jan. 16, 65 m.c. of radium in left lobe 6 hours, and in right lobe 6 hours.

Feb. 19 (examination with Dr. Keyes): His prostate felt irregular, but there was nothing absolutely characteristic of carcinoma. He is a veteran and had offered his services to his country in the event of war. I also learned that he wishes to get married.

Case XVII.—H. C. A. Age 62. Chief complaints are urgency of urination, sometimes bleeding, and for the past year nocturnal frequency. Now he arises four times at night. His residual was one ounce, and his prostate was small, irregular and stony hard.

Sept. 25, 50 m.c. of radium in right lobe 4 hours, and in left lobe 4 hours.

Jan. 31, he reported that he had considerable burning after the irradiation. He was now urinating 3 times at night, and by day every 2½ hours. He had ½ ounce residual urine, prostatic examination (with Dr. Keyes) showed a little, hard lump beginning in the left center, and going to left lobe. Right lobe possibly a little irregular. A decided change from the first examination.

Mar. 1, 50 m.c. in right and 50 in left lobes for 6 hours.

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